COAL & ALLIED

Managed by Rio Tinto Coal Australia

Appendix 1

Summary of Complaints 2016

Hunter Valley Operations Complaints 2016

Type	Month	Date	Time	Method Received	Location
Noise	January	10/01/2016	10:31:00 PM	Complaints Hotline	Jerrys Plains
Blast	January	13/01/2016	11:18:00 AM	Telephone	Long Point
Blast	February	23/02/2016	12:49:00 PM	Complaints Hotline	Jerrys Plains
Dust	February	25/02/2016	5:10:00 PM	Complaints Hotline	Maison Dieu
Noise	March	28/03/2016	10:46:00 PM	Complaints Hotline	Jerrys Plains
Noise	May	8/05/2016	9:53:00 PM	Complaints Hotline	Maison Dieu
Noise	May	8/05/2016	10:03:00 PM	Complaints Hotline	Maison Dieu
Blast	May	13/05/2016	3:58:00 PM	Telephone	Long Point
Noise	July	22/07/2016	8:24:00 AM	Complaints Hotline	Maison Dieu
Noise	July	22/07/2016	6:14:00 PM	Complaints Hotline	Maison Dieu
Noise	July	22/07/2016	6:22:00 PM	Complaints Hotline	Maison Dieu
Noise	July	22/07/2016	8:17:00 PM	Complaints Hotline	Maison Dieu
Noise	July	22/07/2016	11:08:00 PM	Complaints Hotline	Maison Dieu
Dust	July	26/07/2016	2:25:00 PM	Complaints Hotline	Long Point
Blast	July	29/07/2016	2:47:00 PM	Complaints Hotline	Long Point
Noise	September	9/09/2016	12:02:00 PM	Telephone	Jerrys Plains
Noise	September	11/09/2016	9:54:00 PM	Complaints Hotline	Maison Dieu
Noise	September	22/09/2016	10:37:00 PM	Complaints Hotline	Maison Dieu
Light	September	22/09/2016	10:39:00 PM	Complaints Hotline	Maison Dieu
Noise	September	22/09/2016	10:39:00 PM	Complaints Hotline	Maison Dieu
Dust	October	13/10/2016	11:50:00 AM	Telephone	Maison Dieu
Blast	October	26/10/2016	1:07:00 PM	Via EPA*	Long Point
Noise	October	30/10/2016	6:50:00 AM	Complaints Hotline	Maison Dieu
Noise	October	30/10/2016	8:52:00 AM	Complaints Hotline	Maison Dieu
Noise	December	24/12/2016	8:40:00 AM	Complaints Hotline	Maison Dieu
Noise	December	24/12/2016	8:53:00 AM	Complaints Hotline	Maison Dieu

*EPA - Environmental Protection Authority

Appendix 2

Ground Water Impacts Reports

Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

HVO North

2016 Annual Review

Prepared for
Coal & Allied Operations Pty Ltd

Project No. G1809A March 2017
www.ageconsultants.com.au ABN 64 080 238 642

Document details and history

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Australasian Groundwater and Environmental Consultants Pty Ltd

AGE Head Office
Level 2 / 15 Mallon Street,
Bowen Hills, QLD 4006, Australia
T. +61 7 3257 2055
F. +61 7 3257 2088
brisbane@ageconsultants.com.au

AGE Newcastle Office
4 Hudson Street,
Hamilton, NSW 2303, Australia
T. +61 2 4962 2091
F. +61 2 4962 2096
newcastle@ageconsultants.com.au

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Report on

HVO North
2016 Annual Review

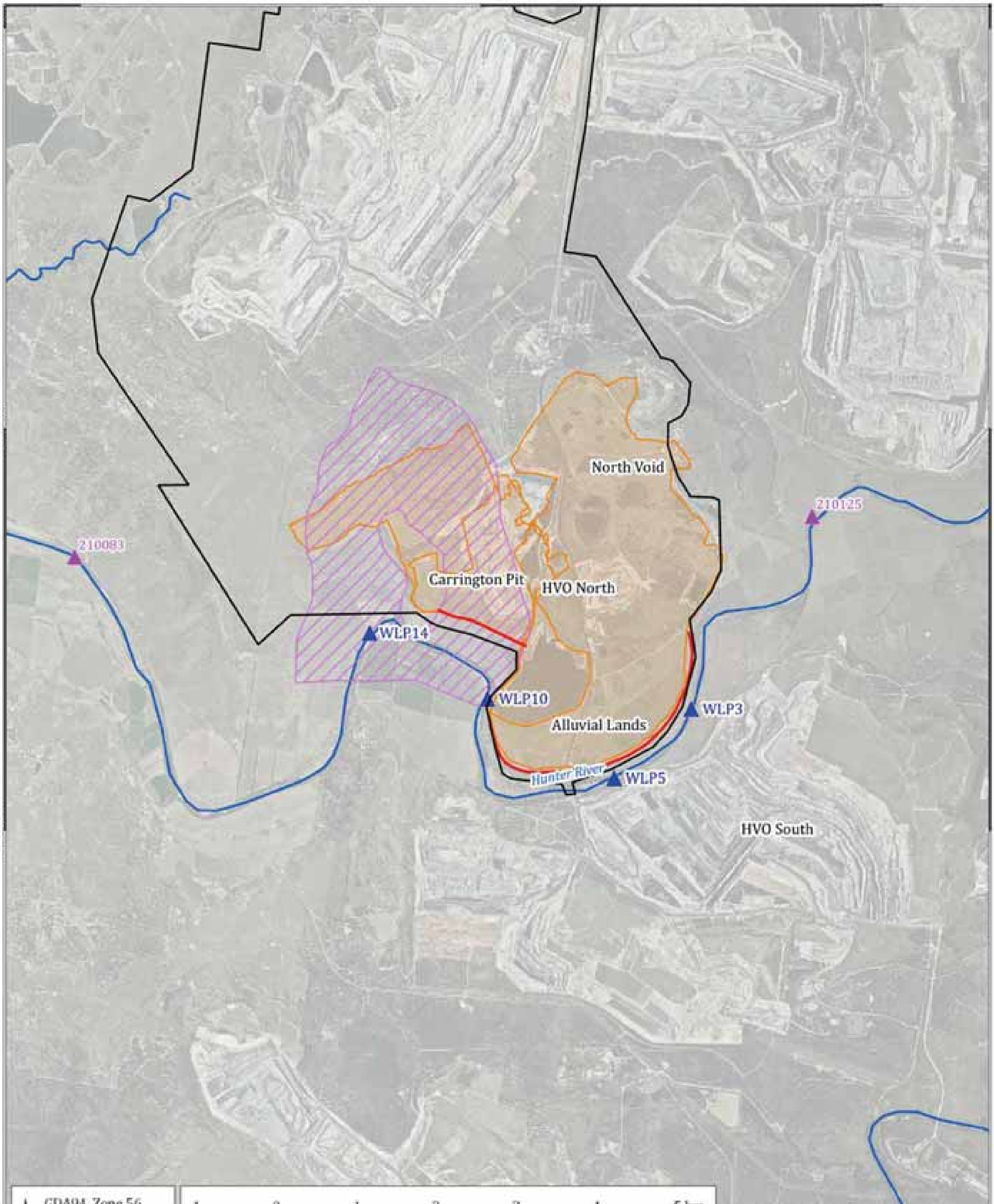
1 Introduction

The Hunter Valley Operations (HVO) mining complex is located approximately 20 km north-west of Singleton, NSW. The Hunter River runs through HVO dividing it into two separate mining areas known as HVO North and HVO South (Figure 1.1). This report focuses on HVO North (the Project area), located approximately 500 m to the north of the Hunter River.

HVO is owned by Rio Tinto Coal Australia (RTCA) and operated by Coal & Allied Operations Pty Ltd (Coal & Allied). Coal & Allied commissioned Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to review the impacts of mining on groundwater systems within the Project area for the 2016 calendar year. The annual review included:

- preparation of water quality tables and graphs;
- assessment of compliance with trigger values adopted in the site Water Management Plan (WMP);
- preparation of water table and piezometric contours from monitoring data pertaining to the Project area;
- assessment of alluvial sediments and Permian strata groundwater flows over the 2016 monitoring period; and
- estimation of groundwater take from the Hunter River Alluvium.

This report also assesses compliance with consent comittments for Alluvial Lands Bore licence 20BL173587-89 & 20BL173847 (recently replaced by WAL40462), specifically conditions 10 and 11.



HVO North - 2016 Annual Review (G1809A)

Project area

AGE

DATE 09/03/2017

FIGURE No: 1.1

2 Project setting

2.1 Mining

Operations commenced at HVO North in 1979, with much of the project area now extensively mined. Several open-cut operations have been completed, backfilled with spoil and rehabilitated. The rehabilitated pits include:

- 'North Void', which was mined from 1979 to around 2008 to the base of the Vaux Seam; and
- 'Alluvial Lands', which was the southern extension of North Void, mined from 1993 to 2003 to the base of the Vaux Seam.

Mining is currently active in the Carrington Pit, which commenced operations in August 2000 with previously mined areas now backfilled and rehabilitated (Figure 1.1). The Carrington Pit is located approximately 500 m to the north of the Hunter River. In 2010 a barrier wall constructed between the Carrington Pit and the Hunter River alluvium to:

- enable continued mining at Carrington Pit;
- conserve the Carrington Billabong, which contains groundwater dependent vegetation;
- minimise leakage from the alluvium to the open-cut; and
- contain groundwater within the mine, following mine closure.

The barrier wall was constructed as a compacted clay buttress wall, against an existing levee that extended across the eastern limb of a Tertiary palaeochannel. The extent of the barrier wall and the location of the Carrington Billabong are shown in Figure 1.1.

Several other mines operated by Coal & Allied surround the Project area, including HVO South, located south of the Hunter River, and West Pit which forms part of HVO North Consent, located north of the Project area. Other surrounding mines include the Ravensworth Operations open-cut and underground mines, located north-east of the Project area.

2.2 Climate

The climate of the area is temperate, and characterised by hot, wet summers and mild, dry winters. Coal & Allied monitor local climatic conditions at the HVO Corp Meteorological Weather Station. Table 2.1 below summarises the monthly temperature and rainfall records.

Table 2.1 Climate averages: HVO Corp. Meteorological Data 2016

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean max temp (°C)	29	31	30	27	22	17	17	19	21	23	30	33	n/a
Mean min temp (°C)	17	18	16	14	11	8	7	6	10	11	14	17	n/a
Mean monthly rainfall since 2007(mm)	81.0	75.1	69.4	47.8	32.4	71.5	29.9	37.8	38.5	34.6	95.0	77.9	690.9*
Total monthly rainfall 2016 (mm)	202.4	10.0	45.2	6.6	20.6	81.4	38.0	22.0	87.0	39.0	60.4	80.4	693.0

Note: **Mean Annual average (2007-2016)*

The total annual rainfall for 2016 was 693 mm which was very close to the average recorded since 2007 of 691 mm. Significant deviations from the monthly mean were recorded in January and September with twice the mean monthly rainfall. In contrast, February and April recorded seven times less than the mean rainfall.

To better understand the long term trends in monthly rainfall the Cumulative Rainfall Departure (CRD) was calculated for the period 2007 to 2016 using the data collected at the HVO Corp Weather Station. The CRD shows trends in rainfall relative to the long term average, and provides a historical record of relatively wet periods and droughts. A rising trend in slope in the CRD plot indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average.

The CRD graph for the period 2007 to 2016 (Figure 2.1), indicates that the site experienced relatively stable rainfall with a significantly higher than average event in January. The CRD is discussed later in the report as it often is related to groundwater levels and an indicator of rainfall recharge to groundwater systems.

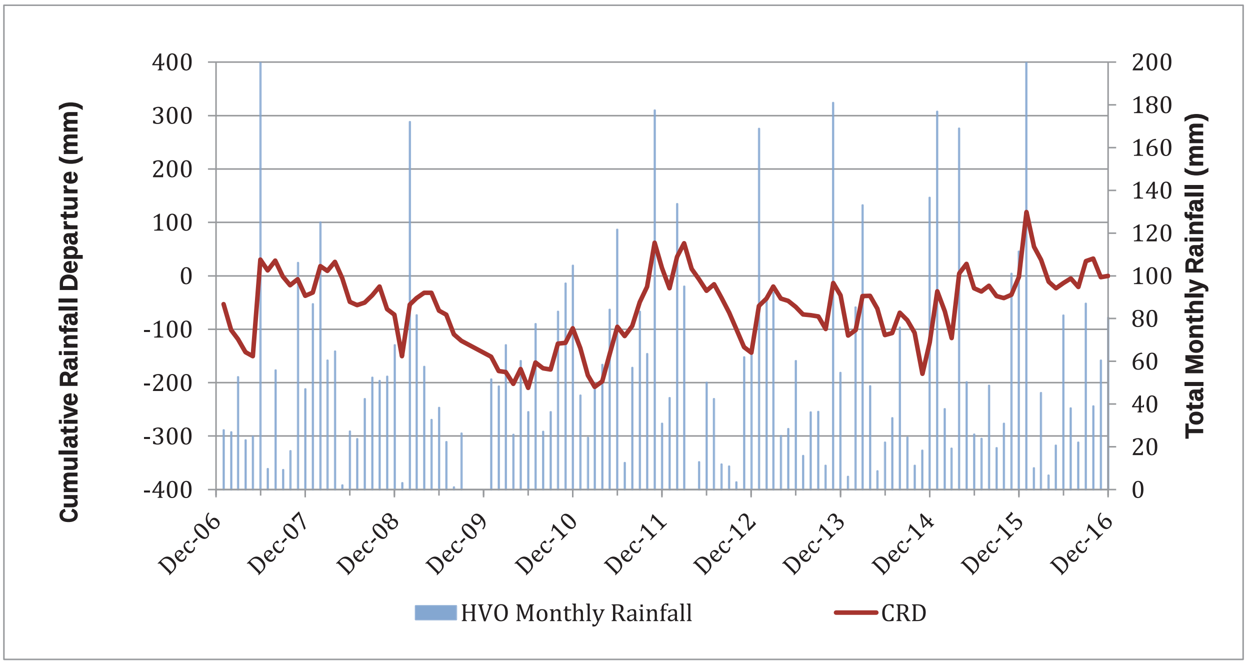


Figure 2.1 CRD and monthly rainfall records

2.3 Surface water

Coal & Allied record the water level within the Hunter River on a monthly basis at four gauging stations. Figure 1.1 shows the location of the gauging stations (WLP3, WLP5, WLP10, and WLP14), with the monthly stream level provided in Table 2.2.

Table 2.2 Hunter River water elevation monitoring (mAHD) - HVO Stations

Station ID	Easting	Northing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WLP3	312613	6401505	55.09	55.03	54.78	54.73	54.86	54.88	55.21	55.65	55.57	55.13	55.29	54.85
WLP5	311655	6400647	56.09	55.93	55.79	55.79	55.83	55.89	56.18	56.72	56.59	56.11	56.26	55.92
WLP10	310080	6401634	58.75	58.67	58.43	58.43	58.52	58.55	59.96	59.45	59.28	58.82	59.09	58.51
WLP14	308598	6402453	60.48	60.39	60.25	60.20	60.28	60.36	60.60	60.92	60.79	60.52	60.64	60.32

The data indicates stream levels were relatively stable over 2016, recording an average level of 55.1 m and 60.5 m at the downstream (WLP3) and upstream (WLP14) gauges respectively. The New South Wales Department of Primary Industries – Water (DPI Water) also record stream levels within the Hunter River at gauging stations upstream and downstream of HVO North (Figure 1.1). Figure 2.2 shows the daily river levels recorded at Station 210083 (upstream of HVO North at Liddell), and at Station 210125 (downstream of HVO North), along with the monthly stream levels recorded at the HVO stations. The total monthly rainfall recorded by the HVO Corp Meteorological Weather Station is also shown.

The water level and flow rate within the Hunter River is regulated by releases of water from the upstream Glenbawn Dam, which maintains a relatively constant baseflow through HVO. The water level within the river does rise in response to rainfall events, typically peaking two to three days after the event, and receding over about ten days. As shown in Figure 2.2, rises in stream levels correspond with rainfall events, with the constant baseflow maintained by releases from Glenbawn Dam during drier periods.

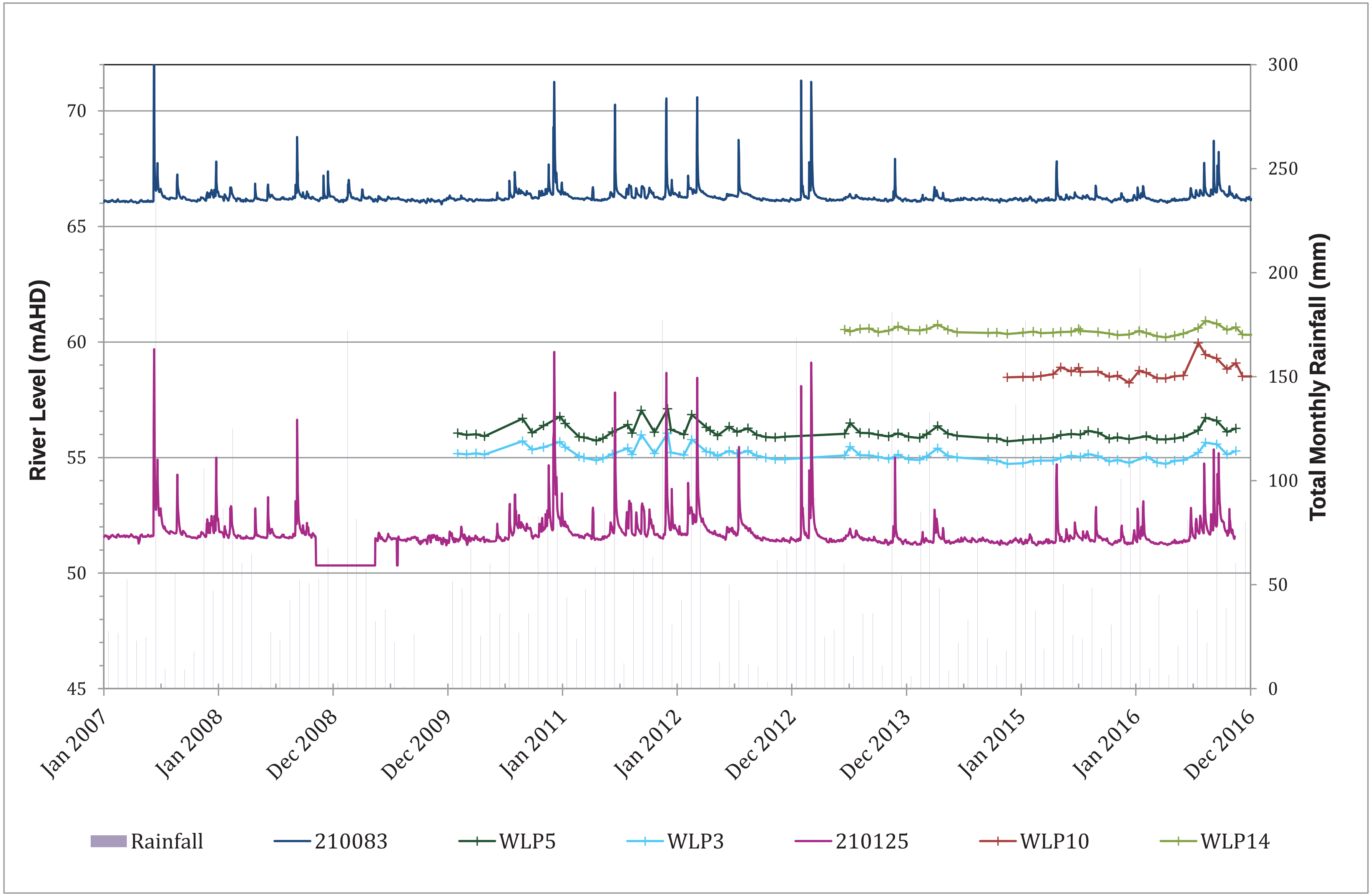


Figure 2.2 Hunter River water levels vs total monthly rainfall

2.4 Geology

The HVO mine and surrounds is characterised by two distinct geological units, namely Quaternary alluvium occruing within the Hunter River flood plain, and the Permian coal measures that form the bedrock. Figure 2.4 shows the surface geology within the region and is based on the 1:100,000 scale geological map, published by the Department of Mineral Resources (Glen & Beckett, 1993). Figure 2.3 summarises the stratigraphic sequence for the HVO area.

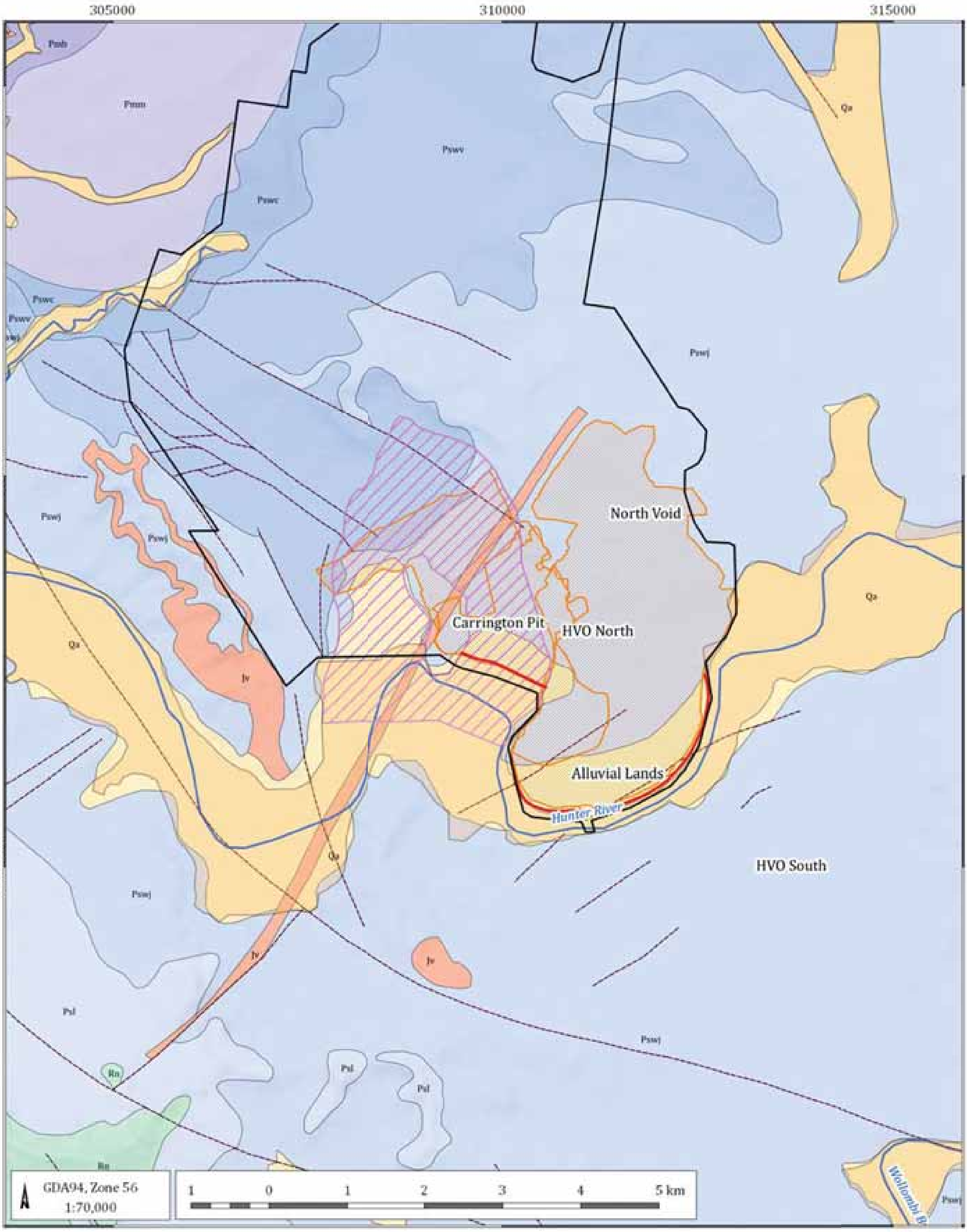
<table>
<tr><td rowspan="21">SINGLETON SUPER GROUP</td><td rowspan="21">WITTINGHAM COAL MEASURES</td><td colspan="3">DENMAN FORMATION</td></tr>
<tr><td rowspan="19">JERRYS PLAINS SUBGROUP</td><td>MOUNT LEONARD FORMATION</td><td>WHYBROW SEAM</td></tr>
<tr><td colspan="2">ALTHORPE FORMATION</td></tr>
<tr><td rowspan="4">MALABAR FORMATION</td><td>REDBANK CREEK SEAM</td></tr>
<tr><td>WAMBO SEAM</td></tr>
<tr><td>WHYNOT SEAM</td></tr>
<tr><td>BLAKEFIELD SEAM</td></tr>
<tr><td colspan="2">SAXONVALE MBR</td></tr>
<tr><td rowspan="2">MOUNT OGILVIE FORMATION</td><td>GLEN MUNRO SEAM</td></tr>
<tr><td>WOODLANDS HILL SEAM</td></tr>
<tr><td colspan="2">MILBRODALE FORMATION</td></tr>
<tr><td rowspan="3">MOUNT THORLEY FORMATION</td><td>ARROWFIELD SEAM</td></tr>
<tr><td>BOWFIELD SEAM</td></tr>
<tr><td>WARKWORTH SEAM</td></tr>
<tr><td colspan="2">FAIRFORD FORMATION</td></tr>
<tr><td rowspan="5">BURNAMWOOD FORMATION</td><td>MOUNT ARTHUR SEAM</td></tr>
<tr><td>PIERCEFIELD SEAM</td></tr>
<tr><td>VAUX SEAM</td></tr>
<tr><td>BROONIE SEAM</td></tr>
<tr><td>BAYSWATER SEAM</td></tr>
<tr><td colspan="3">ARCHERFIELD SANDSTONE</td></tr>
</table>

Figure 2.3 Wittingham Coal Measures Stratigraphic Table

Note: *Carrington Pit – target coal seams*

The Quaternary alluvium occurring along the Hunter River contains two main depositional units, a surficial fine grained sediment (clay, silt and sand) overlying a coarser basal material (sand and gravel). The alluvial sediments are generally confirmed to the currenty course of the Hunter River. An ancient river meander carved into the underlying Permian sediments and infilled with alluviual sediments does occur to north of the Hunter River. The palaeochannel deposits consist of silt, sand and gravel (Figure 2.4).

The Permian sediments underlying the Quaternary alluvium comprise sequences of coal seams seperated by layers of sandstone, siltstone, tuffaceous mudstone and conglomerate generally referred to as overburden and interburden in the context of mining. The regular layered sedimentary sequence dips gently to the south-west. The Wittingham Coal Measures contains the main economic coal seams of the Project area, including the Burnamwood Formation which is the sequence being mined at Carrington Pit (Figure 2.4). The Archerfield Sandstone and the Vane Subgroup underlie the Jerrys Plains Subgroup and are not disturbed by mining.



LEGEND

- Mine lease
- Spoil
- Paleochannel (MER, 2005)
- Quaternary alluvium (1:25k AGE)
- Barrier wall
- Regional fault
- Major drainage

Geology - Hunter Coalfield Regional 100k

- Qa - Quaternary alluvium
- Jv - Jurassic volcanics
- Rn - Narrabeen Group
- Psl - Newcastle Coal Measures
- Pswj - Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pmb - Braxton Formation

HVO North - 2016 Annual Review (G1809A)

Geology

AGE

DATE 09/03/2017

FIGURE No: **2.4**

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2.5 Hydrogeology

Three main groundwater systems occur at HVO north; the Hunter River alluvium, the palaeochannel alluvium; and the Permian coal measures. The Project area also includes several mined-out areas that have been backfilled below the water table with mine spoil (overburden/Interburden). These areas have formed groundwater systems due to recharge from groundwater, rainfall and in some cases seepage from dams and tailings facilities. Section 2.5.1 to Section 2.5.3 below provides more detail on the hydrogeological characteristics of the alluvium, palaeochannel alluvium and Permian coal measures.

2.5.1 Hunter River Alluvium

The Hunter River alluvial aquifer refers to groundwater within the Quaternary alluvium located along the Hunter River. The extent of the Quaternary alluvium is shown in Figure 2.4. The alluvium is generally comprised of 10 m to 20 m of unconsolidated gravels, sands, silts and clays. The alluvium typically includes two to three main stratigraphic units (Mackie, 2005) as follows:

- surface layer comprising of sands, gravels and minor clay;
- middle layer of silty gravels and sands interbedded with silt and clay layers; and a
- coarse cobble-gravel basal section.

Recharge to the alluvium is by direct infiltration of rainfall, with a lesser contribution from upward leakage from the underlying coal measures. Localised recharge also occurs via lateral seepage through the banks of the Hunter River during periods of high flows.

2.5.2 Palaeochannel

The alluvial palaeochannel occurs within the HVO North mine and is located north of the Hunter River and west of the existing Carrington Pit (Figure 2.4). The alluvial palaeochannel is generally range from 12 m to 20 m in thickness and is infilled with unconsolidated gravels, silts and clays. (MER, 2010a) concluded the depositional environment of the palaeochannel is a result of flood surge events, resulting in deposition of gravels contiguously with silts and clays. The sequence can be simplified into three main layers which relate to the current day Hunter River alluvial sequence as follows:

- upper layer, comprising thin bands of sand, silt and clay;
- middle layer, which is approximately 3 m to 8 m thick that consists of stiff clays; and a
- basal layer, which is approximately 3 m to 8 m thick comprising of fine to coarse-grained silty clay gravels and cobbles or in some areas, sandy gravels.

2.5.3 Permian coal measures

Permian coal measures underlie the region and from a hydrogeological perspective can be characterised into:

- very low to low permeability and very low yielding sandstone, siltstone and conglomerate interburden / overburden; and
- low to moderately permeable coal seams, each typically ranging in thickness from 2.5 m to 10 m, which are poor water bearing strata, but are the main unit containing groundwater within the Permian sequence.

3 Monitoring programme

Coal & Allied have prepared a Water Management Plan (WMP) for HVO that describes groundwater monitoring programme required annually at HVO North and South. The WMP describes requirements for monitoring groundwater levels and groundwater quality and trigger levels that if exceeded require investigation. The sections below summarise the existing groundwater monitoring network and the trigger levels.

3.1 Monitoring bore network

The groundwater monitoring network at HVO North (excluding West Pit area), consists of 60 monitoring locations. The monitoring sites are largely standard PVC cased monitoring bores with vibrating wire piezometers (VWP) installed in some areas. There are:

- 29 monitoring bores in the Carrington Pit area;
- 23 monitoring bores in the North Void and Alluvial Lands; and
- 8 VWPs.

Figure 3.1 shows the location of each of the monitoring bores, with the construction details summarised within Appendix A. Table 3.1 summaries the geological formations each bore is monitoring.

Table 3.1 Monitoring bore network lithology

Location	Lithology	No. of bores
Alluvial Lands	Alluvium	6
	Permian Coal Seam	1
	Spoil	15
	Unknown	1
Carrington	Alluvium	13
	Permian Coal Seam	9
	Permian Interburden	4
	Spoil	3
	VWP	8

The WMP requires the collection of water level and water quality from the monitoring network on a routine basis. Groundwater levels are measured manually and in some bores this is supplemented with data logger measurements. The water levels are measured on either a quarterly or biannual basis depending on the monitoring site. Samples are collected from the monitoring bores on a quarterly, biannual and annual basis for water quality analysis. The unstable parameter pH, along with electrical conductivity (EC) is measured in the field at the bore site. On a biannual or annual basis samples are collected and sent to an analytical laboratory for a comprehensive analytical suite that includes:

- total dissolved solids (TDS);
- major ions - Ca, Cl, K, Mg, Na, SO_4 (or S);
- total alkalinity, bicarbonate alkalinity, carbonate alkalinity (CO_3), hydroxide alkalinity; and
- trace elements - Al, As, B, Cd, Cu, Hg, Ni, Pb, Se, Zn.

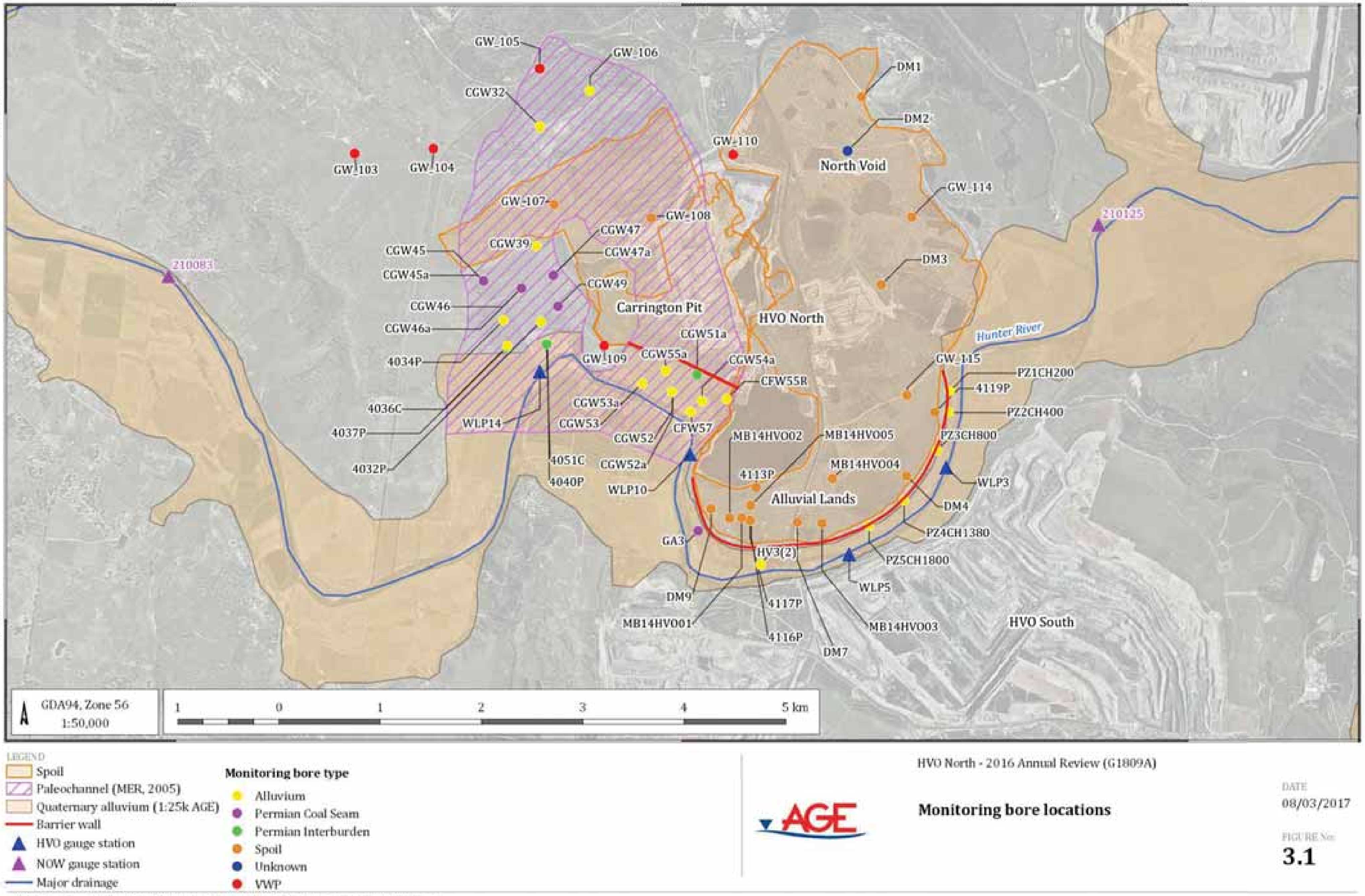
A number of samples are analysed for the above analytical suite, plus the following additional items:

- trace elements - Be, Co, F, Fe, Mn, Sb, SiO_2, Sr; and
- nutrients - NH_3, NO_2, NO_3, P.

3.2 Trigger levels

A percentile based trigger level system has been adopted for pH and EC. In this system, the 95th percentile represents the maximum trigger level, with the 5th percentile used for the minimum pH trigger level. The WMP requires further investigation when:

- three consecutive measurements of EC or pH exceed the trigger values; or
- professional judgement indicates there is potential that a single deviation or a developing trend could result in environmental harm.



HVO North - 2016 Annual Review (G1809A)

Monitoring bore locations

DATE
08/03/2017

FIGURE No:
3.1

G:/Projects/G1809A.RTCA_HVO North Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/03.01_G1809A_Monitoring bore locations.qgs

4 Groundwater quality

Measurement of groundwater EC and pH was conducted at 51 bores over the 2016 monitoring period. In addition, selected bores were sampled for laboratory analysis of major ions and metals. The full suite of water quality results for the 2016 monitoring period is tabulated within Appendix B. Appendix B also contains graphs of water quality trends over time along with relevant trigger levels.

4.1 Field water quality measurements

The graphs and tables within Appendix B are used to identify trends in pH and EC throughout the year and to assess compliance with the requirements of the Water Management Plan. The graphs show the range in groundwater salinity as indicated by EC, which varies from fresh (PZ5CH1800) to saline (4116P), with the lowest EC measured within the Hunter River alluvium in the Alluvial Lands area, and the highest within the Spoil in the Alluvial Lands area. The EC recorded in all the collected samples was less than the respective trigger level, with the exception of:

- Bore CFW55R, which exceeded the trigger level for electrical conductivity of 5,076 µS/cm for all four monitoring rounds. As this bore exceeded trigger levels for three consecutive measurements, investigation is required as per Section 9.2 of the WMP.
- Bore GW__106, which reported an EC measurement (9,540 µS/cm) above the trigger level of 9,216 µS/cm in March 2016. Measurements decreased over the monitoring period, with only one of the four above the respective trigger level.
- Bore 4116P, which exceeded the trigger level of 12,465 µS/cm in December 2016. This bore has displayed increasing EC over the monitoring period with measurements from 10,890 µS/cm to 12,680 µS/cm.
- Bore CGW49, which exceeded the trigger level of 2,776 µS/cm in June 2016. Levels have since returned below the trigger level, suggesting natural variation in measurements.

For the 2016 monitoring period, pH results ranged from 6.2 to 7.9, for the entire available dataset. Samples collected from seven monitoring bores exceeded their respective trigger levels for pH. These bores and their respective measurements can be seen below in Table 4.1, with exceedances in bold text.

Table 4.1 2016 pH exceedances

Bore ID	Feb	Mar	May	Jun	Aug	Sep	Nov	Dec
CGW51A		7.2		7.3		**7.5**		7.2
PZ5CH1800	6.9		7		6.9		**6.5**	
GW_106		**6.7**		6.8		6.8		**6.6**
DM1		**6.4**		6.6		**6.5**		**6.4**
DM3		**6.2**		**6.4**		6.6		**6.3**
GW_114		**6.2**		6.7		6.6		6.6
CFW55R		**6.9**		**6.9**		**6.8**		**6.7**

As shown above in Table 4.1, one of the seven bores exceeded the respective trigger level for three consecutive measurements over the 2016 monitoring period. As such, an investigation is required for bore CFW55R as per Section 9.2 of the WMP. The six remaining bores, while exceeding their trigger levels for pH, did so on less than three occasions, and do not require investigation. These measurements likely relate to natural variation; however, continued monitoring of these sites is recommended to monitor for further exceedances.

4.2 Laboratory analysis

The WMP requires groundwater samples are collected from each monitoring bore annually for laboratory analysis. The review indicates some of the chemical testing committed to within the WMP appears not to have been undertaken. The annual testing data provided for 2016 excluded Cl, bicarbonate alkalinity, carbonate alkalinity, Cd, Cu, Hg, Ni, Pb, Be, Co, F, Sb, $Si0_2$, NH_3, NO_2, NO_3.

5 Groundwater levels

Manual recording of groundwater levels within monitoring bores at HVO North has been undertaken since 2001. The manual water level measurements are also supplemented with water levels recorded automatically by data loggers installed in 16 locations between 2009 to 2014. This report specifically examines trends recorded over the 2016 calendar year; however, data since 2014 is presented to ensure longer term trends are considered. Appendix C contains groundwater hydrographs for each of the bores, with groundwater level contours provided within Figure 5.1 and Figure 5.2.

Groundwater levels were measured at 51 bores across the 2016 monitoring period. Seven bores across the whole 2016 monitoring period were either dry, or had insufficient water for sampling and are likely dry. These bores were CGW45A, CGW46A, CGW47, DM2, GW_101, GW_107, and GW_108. Bore DM9 was out of service, with no data collected during the 2016 monitoring period.

The groundwater levels were compared against the CRD and Hunter River levels recorded at the DPI Water gauging station 210083 located approximately 4 km west of Carrington Pit. The CRD and river level measurements allow the relationship between groundwater levels, rainfall recharge and river connectivity to be better understood. This is important as these natural influences on groundwater levels need to be separated from the potential influence of mining activities Sections 5.1 and 5.2 below discuss further the groundwater levels observed with the alluvial and the Permian groundwater systems respectively.

5.1 Hunter River / Palaeochannel Alluvium

Figure 5.1 shows that groundwater within the Quaternary alluvium generally flows in an easterly ‘downstream’ direction, following the grade within the Hunter River. There are also very gentle gradients from the remaining paleochannel sediments towards the north and the mined areas. This gradient towards the mining areas is less evident further downstream where the alluvial plain narrows.

As discussed, Appendix C contains hydrographs showing the long-term trends in groundwater levels for bores installed within alluvium. The hydrographs from the network of alluvial monitoring bores were grouped according to location as follows:

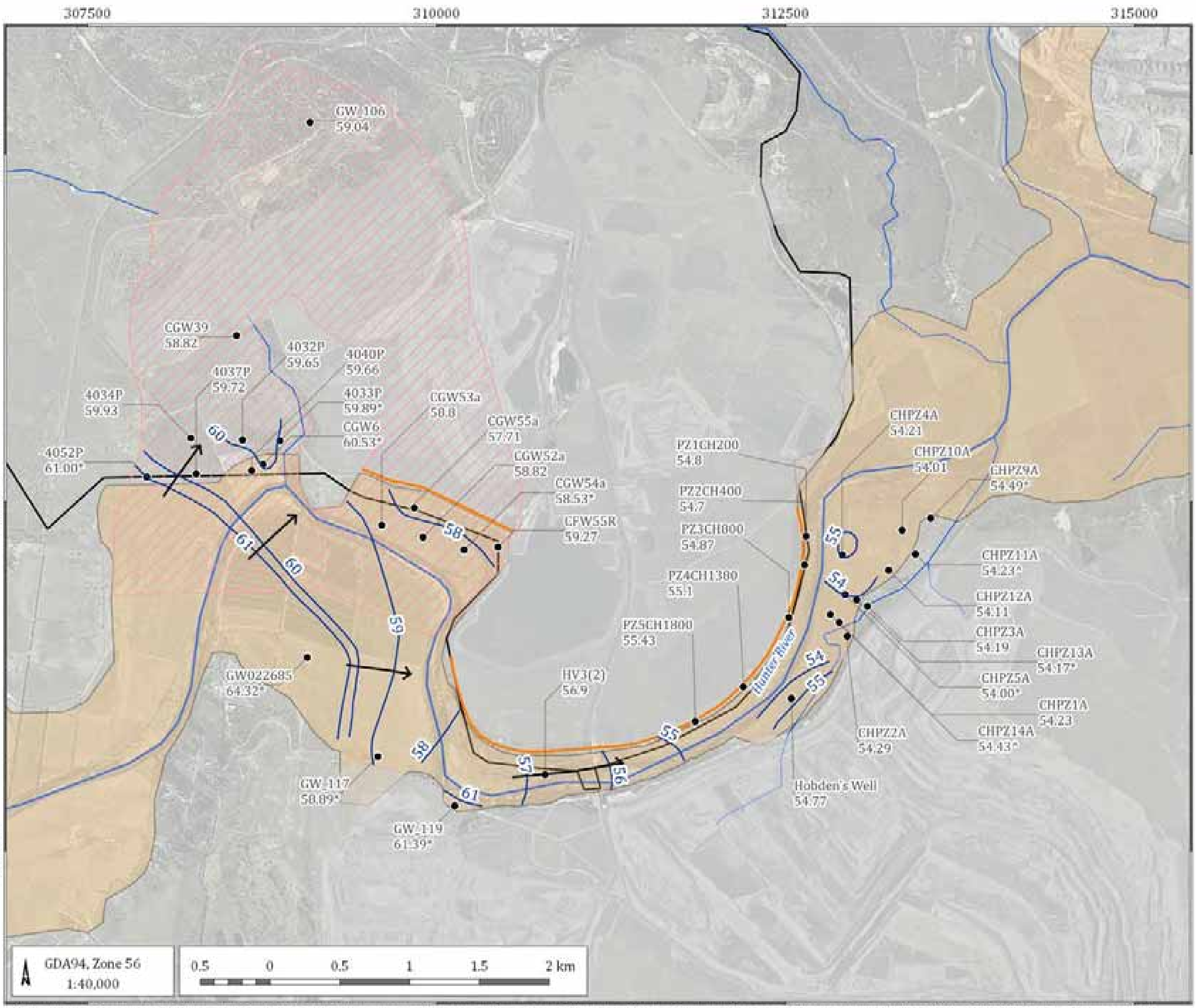
- Carrington West Wing paleochannel.
- Carrington East Wing paleochannel.
- Hunter River alluvium.

These hydrographs from each of these groups are compared with water level records collected from the closest operating Hunter River gauging station. In general the hydrographs show alluvial groundwater levels were relatively stable over the 2016 monitoring period or rose slightly. The sections below discuss the water level records for the three areas in more detail.

5.1.1 Carrington West Wing

The bores within the Carrington West Wing area were further grouped into two zones based on proximity to the Hunter River (less than and greater than 700 m from the Hunter River) (Appendix C - Figures C.1 and C.2 respectively).

Figures C.1 and C.2 indicate the direct hydraulic connectivity between the alluvium and the Hunter River reduces with distance from the river as is expected. Water levels recorded in bores within 700 m of the Hunter River respond to rainfall and changes in river levels. For example bore 4040P located 200 m from the river responds to changes in river level, but this response is more muted within bore 4034P, located 600 m from the River. Bores greater than 700 m from the Hunter River show little or no change in groundwater levels while river levels are fluctuating.



LEGEND

- Mine lease
- Paleochannel (MER, 2005)
- Quaternary alluvium (1:25k AGE)
- Previously mined area
- Groundwater monitoring bore
- Observed water level (mAHD)
- Barrier wall
- Groundwater contour (mAHD)
- Inferred flow direction
- Major drainage

^ Water level February 2016
* Water level September 2015

HVO North - 2016 Annual Review (G1809A)

Alluvium groundwater level contours - May - June 2016

DATE
01/03/2017

FIGURE No:
5.1

G:/Projects/G1809A.RTCA_HVO North Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/05.01_G1809A_Alluvium groundwater level contours - May - June 2016.qgs

5.1.2 Carrington East Wing

In March 2010, a barrier (groundwater cut-off) wall was constructed across the eastern limb of the alluvial sediments, approximately 400 m north of the Hunter River. In general, groundwater levels over the 2016 monitoring period in Carrington East Wing have risen slightly. Fluctuations observed coincide with periods of higher than average rainfall, as shown in Figure C.3 and Figure C.4. Again the influence of the Hunter River depends on proximity with groundwater levels closer to the river (<250 m) responding more to fluctuations in river levels than those located further away (>250 m).

5.1.3 Hunter River Alluvium

A barrier wall is also present between the Hunter River and the former Alluvial Lands mining area that is now backfilled and rehabilitated. Six monitoring bores record groundwater levels within the Hunter River alluvium adjacent to the barrier wall. Groundwater levels remained relatively stable over the 2016 monitoring period, with fluctuations observed coinciding with peak rainfall events and changes in river levels. The groundwater levels, as shown in Figure C.5, respond rapidly to changes in conditions in the Hunter River, are well correlated with levels measured at WLP3 and WLP5. Again this indicates connectivity between the Hunter River and the alluvium groundwater system.

Figure C.6 compares the groundwater level elevation in the alluvium and the spoil on the eastern part of the Alluvial Lands and therefore indicates the effectiveness of the barrier wall. Historically, alluvial groundwater levels have been higher than spoil levels, with spoil levels increasing during periods of high rainfall. Throughout the 2016 monitoring period, alluvial groundwater levels were higher than those observed within the spoil, with the exception of monitoring events in the first quarter of the year, which coincides with the peak rainfall event in January and the wetter than average period shown on the CRD. During the second half of the year, fluctuations can be seen in the alluvium coinciding with changes in water levels, with relatively stable groundwater levels in the spoil. These trends are in line with historic measurements, and shows the barrier wall is continuing to be effective in preventing groundwater discharge between the two zones. The lower water levels recorded within the spoils suggest connectivity through the coal seams under the Hunter River and into the HVO South mining areas.

5.2 Permian coal measures

5.2.1 Permian coal seams

Appendix C, Figure C.7 contains hydrographs for bores screened within the Permian coal measures. There is an insufficient number of bores spread across the Project area, intersecting the same coal seam to display reliable groundwater contours for the Permian coal measures. In general the hydrographs indicate the Permian groundwater levels remained relatively stable for the 2016 monitoring period – the exceptions were:

- Fluctuations of up to +2.94 m and -1.24 m observed at bore CGW45, with an overall 18.42 m rise since June 2015. Water levels for the 2016 monitoring period were recorded at or near ground level. This is a significant anomaly that is difficult to explain.
- Fluctuations of up to -5.05 m and +5.09 m were recorded at bore CGW47A.
- Bore CGW46A, screened in the Broonie Seam, remained dry throughout the 2016 monitoring period.

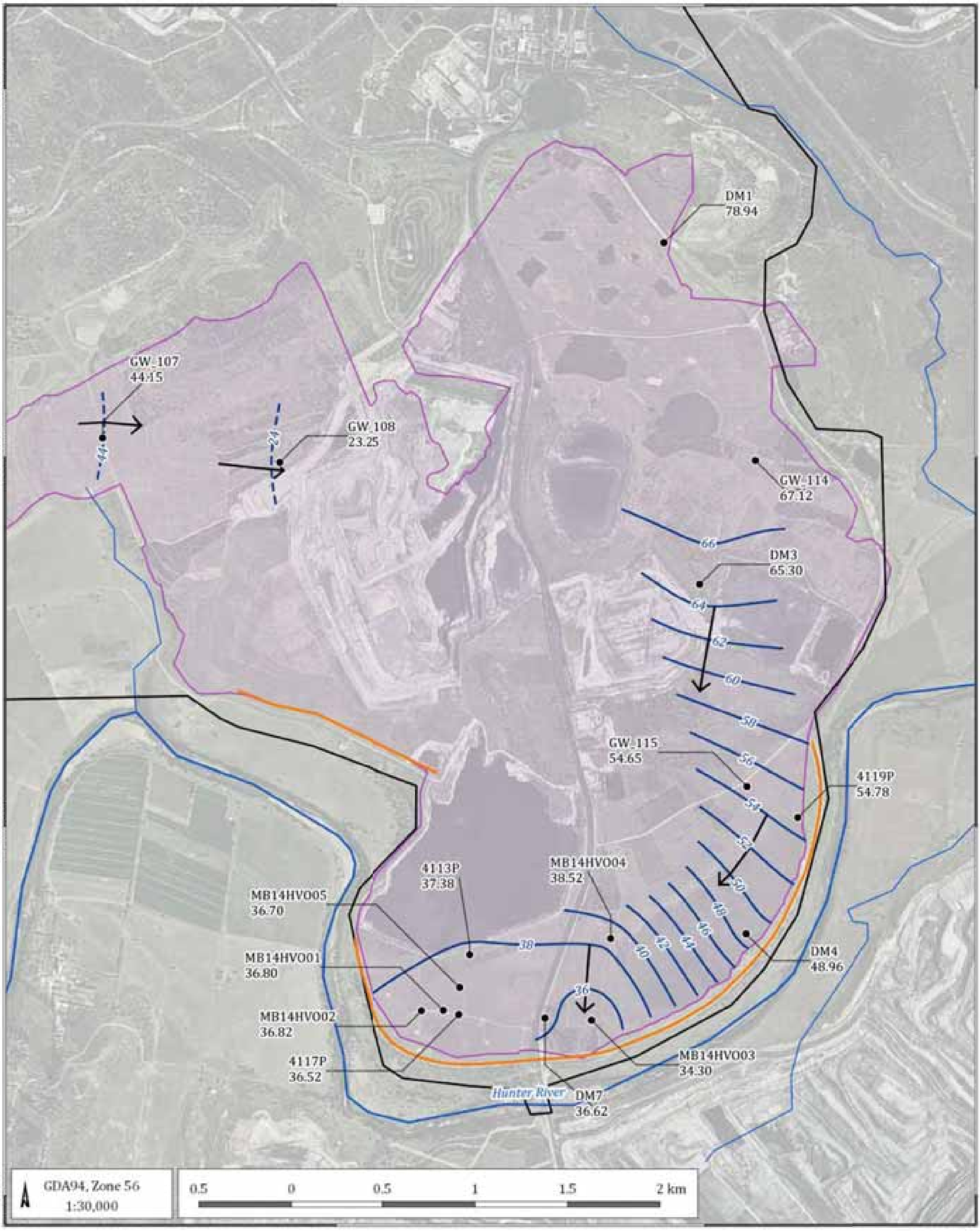
5.2.2 Permian interburden

Appendix C, Figure C.8 presents the hydrographs for bores screened within the Permian interburden. The available groundwater level data for the 2016 monitoring period indicates that:

- Bore 4036C, 4051C, and CGW51A, remained relatively stable to slightly rising, with fluctuations of +0.12 m, +0.70 m, and +0.52 m respectively.
- Bore GW_101 recorded no groundwater measurements for the 2016 monitoring period due to being dry, or having insufficient water for sampling, likely being dry.
- Bore CFW59 was not monitored for the 2016 monitoring period, and is not part of the current monitoring programme.

5.3 Spoil

Appendix C, Figure C.9 presents hydrographs for bores screened within the spoil. The water level records indicate relatively stable groundwater levels within the mine spoils over the 2016 monitoring period. Groundwater contours for June 2016, presented in Figure 5.2, indicate that groundwater within the spoil to the west of the site is flowing towards the Carrington Pit void. Within the rehabilitated spoil at North Pit and Alluvial lands, groundwater levels are 38 mAHD near the North Void TSF. Further south at Alluvial Lands, the spoil water levels decrease to 34 mAHD, indicating drawdown within the spoil towards active mining at Cheshunt Pit (HVO South). Westerly flow within the spoil towards Carrington Pit appears to be inhibited by a band of undisturbed Permian coal measures between the two mined out areas, which acts as a natural barrier.



LEGEND

- Spoil
- Mine lease
- Barrier wall
- Major drainage
- Groundwater monitoring bore, Observed water level (mAHD)
- Flow direction

Groundwater contour (mAHD)

- interpolated
- inferred

HVO North - 2016 Annual Review (G1809A)

Spoil groundwater level contours - June 2016

AGE

DATE 01/03/2017

FIGURE No: **5.2**

G:/Projects/G1809A.RTCA_HVO North Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/05.02_G1809A_Spoil groundwater level contours - June 2016.qgs

6 Water take and licensing

6.1 Legislation

Department of Primary Industries – Water (DPI Water) manage groundwater in the region in accordance with the *Water Management Act 2000*, under which Water Sharing Plans (WSP) have been developed to share water resources equitably among users. At HVO North the following plans apply:

- Alluvial groundwater - Hunter Unregulated and Alluvial Water Sources WSP;
- Hunter River surface water - Hunter River Regulated Water Source WSP; and
- Bedrock groundwater including coal measures - North Coast Fractured and Porous Rock WSP.

The New South Wales Aquifer Interference Policy (AIP) requires mines account for all 'water take' due to mining, both directly and indirectly. The 'water take' must be accounted for with water access licenses issued by the DPI Water under the relevant WSP.

6.2 Methods to estimate 'water take'

Mining activities create a zone of low or zero water pressure within the mining area, which induces groundwater to flow directly into the active mining area. At many coal mines, the volume of groundwater ingress into the active mining areas cannot be directly measured because it is volumetrically relatively small, and not collected at a single point. Groundwater entering the mining area is also subject to range of processes including evaporation from the mine face, mixing with surface runoff and adhering to mined materials.

Mining typically also reduces groundwater pressures in strata directly surrounding the mining area. Where there is a change in water level and pressure due to the mining this is typically referred to as the 'zone of influence' or the 'cone of depression'. The pressure changes within the zone of influence can change the volumes of groundwater moving into aquifers adjacent to mining. This results in an 'indirect take' of groundwater, sometimes referred to as a 'passive take'. The indirect take does not necessarily flow into the active mining area, but represents a reduced flow to aquifers not being directly excavated by mining.

The currently active Carrington Pit does not record continuous measurable groundwater inflow to the mining areas, as evaporation from the mine face, mixing with surface runoff and adhering to mined materials prevents direct measurement. In the absence of direct measurements, of 'water take', models are required to estimates the volume of water taken during mining operations. There are three types of models commonly used for this purpose:

1. numerical groundwater flow models;
2. analytical groundwater flow models; and
3. water budget models.

Over time Coal & Allied have utilised all of the above methods to estimate volumes of direct and indirect water take from the groundwater systems at HVO North. The Carrington West Wing EIS (Mackie Environmental Research 2010b) is the most recent public domain numerical groundwater flow model with estimates of groundwater ingress into the HVO North mining areas. Previous annual reviews have also utilised analytical methods to estimate volumes of groundwater draining indirectly from the alluvial strata. Coal & Allied also have developed mine water balance models for HVO North for water management purposes that have potential to provide back-calculated estimates of groundwater ingress to mining areas. All of these methods have limitations, and ultimately provide an **estimate only** of an immeasurable quantity of water. The estimates cannot be directly validated, as there is no measured data to compare against modelled estimates; however the estimates from the various modelling methodologies can be compared with each other. The sections below present estimates of 'water take' from numerical and analytical methods, and compare the results with WALs held.

6.3 Numerical modelling estimates of 'water take'

Table 6.1 below summaries the water access licenses (WAL) held by Coal & Allied to account for groundwater directly intercepted by mining activities, and the estimates from the most recent numerical modelling undertaken for HVO North by Mackie Environmental Research (2010b).

Table 6.1 Water licenses and numerical modelling estimates of 'water take' at HVO North

Water Sharing Plan	Entitlement (ML) and WAL	Estimated maximum direct take (ML)[1]
North Coast Fractured and Porous Rock Groundwater [2]	3,040 (WAL40462, WAL40466, WAL40463)	32
Hunter Regulated River	3,165 (WAL962)	36.5
Hunter Unregulated and Alluvial Water Sources	65 (WAL18158)	36.5

1. *From estimated presented in Mackie Environmental Research (2010b)*
2. *This Water Sharing Plan commenced in July 2016 midway through the annual review period. The area was formerly regulated under the Water Act 1912, and as part of the change in legislation water licenses are being converted to new formats. It is understood the conversion process is still underway at the time of writing.*

The most recent groundwater modelling conducted by Mackie Environmental Research (2010b) for HVO North focussed on mining of the 'West Wing' coal deposit, which underlies the western arm of the Hunter River paleochannel. The modelling predicted a peak groundwater ingress of 32 ML/year from the Permian strata into the West Wing area. Coal & Allied are yet to commence mining of the West Wing. This modelling assumed closure of Carrington pit by 2016, so an estimate of groundwater ingress to the current pit configuration is not available from this work.

The numerical modelling also provided estimates of the indirect take of water from the Hunter River alluvial aquifer and the Hunter River which are also presented in Table 6.1. The numerical modelling indicates in the absence of barrier walls the alluvial flow towards the mine in the western arm of the paleochannel is 73 ML/year and the eastern arm is 36.5 ML/year. When the barrier walls are installed Mackie Environmental Research predicted flux would reduce to zero. As the western barrier wall has not been installed the modelling results suggest a current day groundwater influx from the alluvium through the Western arm of 73 ML/year, and 0 ML/year from the eastern arm where the barrier wall is present, a total of 73 ML/year. To prevent double accounting of alluvial groundwater that enters the underlying alluvium from the Hunter River, the water take of 36.5 ML/year from the river must be removed, providing the estimate of 36.5 ML/year 'water take' for the alluvial groundwater system.

Whilst the mining schedules have differed from those represented within the Mackie Environmental Research numerical modelling, it is clear the volumes of groundwater ingress estimated to be entering the mining areas are significantly less than the entitlements held for accounting purposes under the AIP.

6.4 Analytical estimates of 'water take'

As discussed previously, analytical methods can also be used to estimate the volume of groundwater ingress to the mining area and the indirect take from the Hunter River alluvium. Previous annual reviews for both HVO North and HVO South have utilised an analytical method to estimate the transfer of alluvial and Permian groundwater into the mining areas.

As shown in Figure 5.1 previously there is very slight hydraulic gradient through the paleochannel alluvium towards the north where the mined areas occur. This indicates a very slight flux of alluvial groundwater through or under the barrier wall and into Carrington.

The following section details the estimated loss of alluvial groundwater due to mining operations at the Project area, based on calculations using "snap-shot in time" data. Groundwater leakage from coal seams and alluvium (through the barrier wall) into the pit (Q_{XY}) were calculated by applying Darcy's Law (Equation 1).

Darcy's Law:

$$\boldsymbol{Q = KiA} \qquad (Equation\ 1)$$

where:

Q is the amount of water discharged (m^3/day)
K is the hydraulic conductivity (m/day)
i is the hydraulic gradient (dimensionless)
A is the area (e.g. exposed coal seam) (m^2)

The results, shown in Table 6.2, indicate that approximately 51 ML/year of groundwater from the Permian coal measures potentially enters Carrington Pit and approximately 3.6 ML/year of alluvial groundwater potentially seeps through the barrier wall into Carrington Pit.

Table 6.2 Estimated leakage of groundwater into pits

Location	Horizontal hydraulic conductivity (MER, 2010) K_{XY} (m/d)	Horizontal hydraulic gradient (i_{XY})	Pit wall length (m)	Exposed face (m)	Horizontal discharge to Pit Q_{XY} (L/s)	Horizontal Discharge from coal seams to Pit Q_{XY} (ML/year)
Carrington Pit	6.0×10^{-3}	0.37	1,100	60	1.67	51
Carrington Barrier Wall - South	5.8×10^{-4}	1.54	1,100	10	0.12	3.6

Notes: *K_{xy} Hydraulic conductivity derived from MER (2010a) and MER (2010b)*
I_{xy} Horizontal hydraulic gradient
Q_{xy} Volume of groundwater discharging into mine pit

While the estimates of 'water take' provided by the numerical and analytical methods are not the same both methods indicate relatively low volumes of 'water take' due to mining are occurring, and the volumes are less the WAL entitlements used to account for the impacts on groundwater systems.

6.5 Limitations

As discussed above where groundwater systems have a relatively poor ability to transmit groundwater, as occurs at coal mines 'water take' cannot be directly measured, but only estimated indirectly using a variety of modelling methods.

The most recent numerical modelling conducted for the West Wing project does not directly represent the actual sequence of mining that has occurred since 2010, and this therefore introduces some inherent uncertainty when applying the results to the 2016 annual review. The method used by Mackie Environmental Research to estimate the alluvial water take also differs from more recent conservative methods used at the adjacent HVO South mine.

The analytical methods that have been used in previous Annual Reviews are a 2D simplification of a more complex hydrogeological system, and also therefore contain some inherent uncertainty. When applying the analytical method it has been assumed alluvial groundwater moves vertically into the underlying Permian, then moves southward to the HVO south mine, and is therefore accounted for under this mines WALs.

As noted above these limitations mean the 'water take' for 2016 can only ever be an estimate, and different methods will provide differing estimates due to the underlying assumptions. In despite of this the methods indicate relatively low volumes of 'water take' are occurring due to mining, and the volumes are less the WAL entitlements. It is important to note more detailed future numerical modelling may provide different estimates of 'water take'.

7 Alluvial Lands Bore Compliance

Coal & Allied hold one WAL to extract groundwater from bores within mine spoils in the Alluvial Lands area. The bores were formerly licensed under Part V of the Water Act 1912, but were cancelled in 2016 and replaced by a single WAL under the Water Management Act 2000 when the North Coast Fractured and Porous Rock WSP became active. Details for each are as follows:

- WAL40462 (20BL173847) - bore yet to be constructed;
- WAL40462 (20BL173587) - Bore DM9 (in spoil) commissioned but out of service;
- WAL40462 (20BL173588) - Bore DM8 commissioned but out of service; and
- WAL40462 (20BL173589) - Bore DM7 (in spoil) not commissioned.

As mentioned previously, a barrier wall was constructed in 2010 between the Alluvial Lands and the Hunter River alluvium to contain the groundwater within the mine and to protect the Hunter River ecosystem.

The maximum volume of groundwater authorised by the four licences is 2,400 ML from 1 July to 31 June. There was no abstraction from the bores during the reporting period; therefore there was no impact on any aquifers, groundwater dependent ecosystems and stream in the area.

8 Conclusions and recommendations

The groundwater monitoring data for the 2016 calendar year was reviewed and it was concluded:

- Three consecutive measurements of pH and EC over the respective trigger levels were reported at bore CFW55R. Section 9.2 of the WMP requires a site specific investigation into the above exceedences. Bore CFW55R first recorded an increase in salinity and reduction in pH in early 2015. This period does correlate with summer rainfall, which may explain the changes in water level and quality. The water level and quality trends appear to have stabilised, and as the groundwater flux in this area appears towards the mining area, the trigger exceedance is not expected to have impacted upon environmental value or beneficial use. Trigger levels for this bore should be recalculated in 2017 when a stabilised trend has been confirmed.
- Groundwater levels over the site remained relatively stable over the 2016 monitoring period, with the exception of bore CGW45. An increase of 18.42 m was observed since June 2015, a significant anomaly that also requires investigation - this should include inspection and tagging the total depth of the bore, and confirming no damage or obstructions are present.
- The groundwater level data continues to indicate a high degree of connectivity between alluvial groundwater and the surface water when in proximity to the Hunter River.
- Groundwater flows direction with the spoil remains toward the Carrington Pit void in the west, and south towards Cheshunt Pit (HVO South) in the North Pit and Alluvial Lands area.
- Estimates of water take using analytical methods (Darcy's Law) indicate the groundwater intercepted by mining is less than the entitlements held by Coal & Allied to account for this impact. Previous numerical modelling also suggests volumes of water take are relatively low.
- No groundwater has been extracted from the Alluvial Lands bores.

9 References

Glen R.A. and Beckett J., (1993), "*Hunter Coalfield Regional Geology 1:100 000*", 2nd Edition. Geological Society of New South Wales, Sydney.

Mackie Environmental Research, (2005), "*Carrington Extended – Water Management Studies*", prepared for Coal & Allied, in Carrington Pit Extended – Statement of Environmental Effects, Volume 2, Annex D – Groundwater & Surface Water Assessment & Associated Peer Review, September 2005.

Mackie Environmental Research, (2010a), "*Carrington Extended – Review of Mining Related Impacts on the Paleochannel Groundwater System*", report on behalf of Coal & Allied, January 2010.

Mackie Environmental Research, (2010b), "*Carrington West Wing Modification – Groundwater Assessment*", prepared for Coal & Allied, in Carrington West Wing Environmental Assessment (EA), Volume 2, Appendix C – Groundwater Study, March 2010.

Rio Tinto Coal Australia, (2016), "*Hunter Valley Operations Water Management Plan*", May 2016

Appendix A Monitoring bore construction details

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Top of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
HV3	MB	EX	310776	6400546	67.67	0.5	16.6	-	16.7	-	-	-	Hunter River Alluvium	Alluvial Lands
PZ1CH200	MB	EX	312646	6402256	62.22	0.1	10.5	>8.9	11.1	-	-	50	Alluvium	Alluvial Lands
PZ2CH400	MB	EX	312634.55	6402050.63	62.73	0.05	11.12	>9.9	11.2	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ3CH800	MB	EX	312522.15	6401674.08	64.22	-	10.42	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ4CH1380	MB	EX	312195.59	6401175.55	65.03	0.08	14.5	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ5CH1800	MB	EX	311851.97	6400928	66.20	0.08	14.92	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
GA3	MB	EX	310159.21	6400875.91	65.52	-	-	-	-	-	-	-	Coal	Alluvial Lands
GW_114_extra	MB	AD	312272.1	6403981.3	98.19	-	120	111	114	-	-	50	Bayswater Seam	Alluvial Lands
4113P	MB	EX	310729.27	6401303.83	70.41	1.33	66.54	62.9	65.54	-	-	50	Spoil	Alluvial Lands
4116P	MB	EX	310681.13	6400978.14	71.48	1.31	25.8	20.9	23.54	-	-	50	Spoil	Alluvial Lands
4117P	MB	EX	310670.12	6400979.97	71.43	1.22	91	87	87.64	-	-	50	Spoil	Alluvial Lands
4119P	MB	EX	312500.62	6402047.91	64.74	1.23	20.8	14.9	17.54	-	-	50	Spoil	Alluvial Lands
DM1	MB	EX	311778	6405164	103.05	0.32	28.83	-	-	-	-	50	Spoil (Base)	Alluvial Lands
DM2	MB	AD	311640	6404635	106.81	-	-	-	-	-	-	-	Pit Floor	Alluvial Lands
DM3	MB	EX	311971	6403310	94.97	0.83	40.67	50	-	-	-	50	Spoil (Base)	Alluvial Lands
DM4	MB	EX	312222	6401418	65.69	0.84	-	55	-	-	-	50	Spoil (Base)	Alluvial Lands
DM7	MB	EX	311136	6400961	70.39	1.13	-	32	-	-	-	400	Spoil	Alluvial Lands
DM9	MB	AD	310284.43	6401094.95	70.80	1.2	-	32	-	-	-	400	Spoil	Alluvial Lands
GW_114	MB	EX	312272.1	6403981.3	98.19	-	33	27	30	-	-	50	Spoil	Alluvial Lands
MB14HVO01	MB	AU	310587	6401003	71.29	-	90	-	-	-	-	-	Spoil	Alluvial Lands

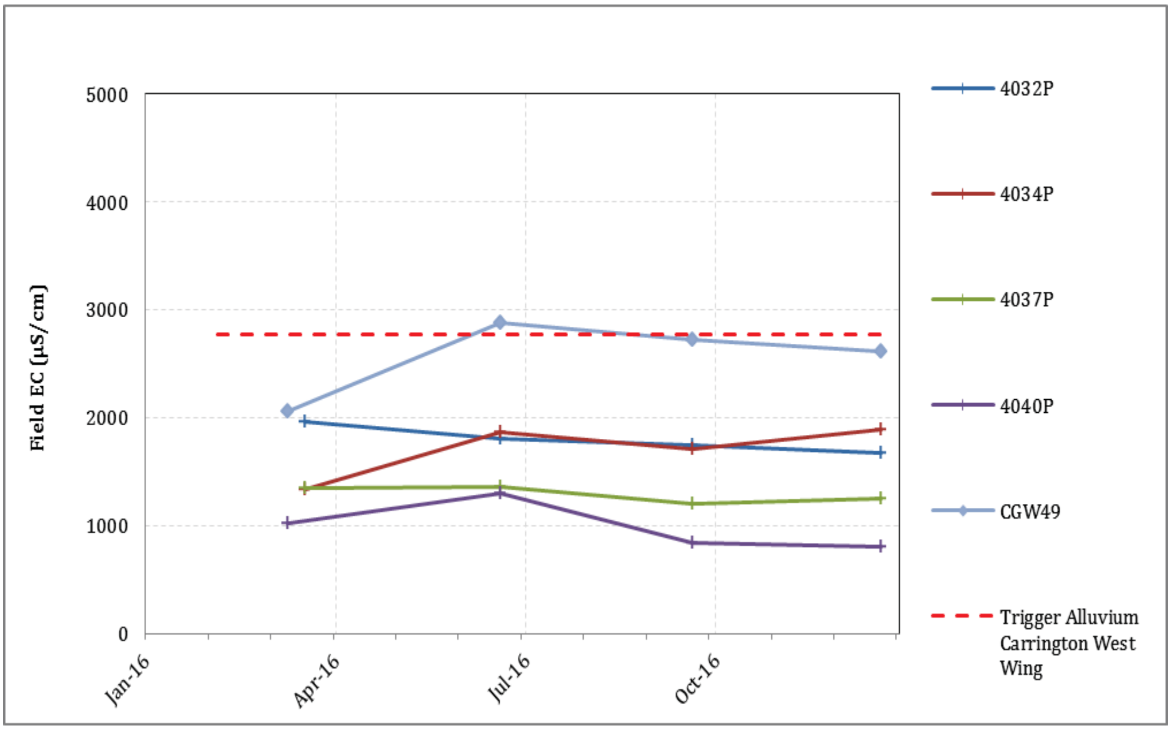
Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Top of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
MB14HVO02	MB	AU	310469	6401001	70.90	-	90	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO03	MB	AU	311387	6400950	67.14	-	80	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO04	MB	AU	311491	6401392	67.06	-	55	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO05	MB	AU	310675	6401127	71.67	-	85	-	-	-	-	-	Spoil	Alluvial Lands
4032P	MB	EX	308608.87	6402944.75	70.29	0.94	14.4	7.44	13.44	-	-	50	Palaeochannel alluvium	Carrington
4034P	MB	EX	308238.86	6402958.62	71.46	0.31	15	5.6	14.6	-	-	50	Palaeochannel alluvium	Carrington
4037P	MB	EX	308276.59	6402701.7	71.77	1.03	15.4	8.28	14.28	-	-	50	Palaeochannel alluvium	Carrington
4040P	MB	EX	308675	6402723.76	70.13	0.97	12.91	5.9	11.9	-	-	50	Palaeochannel alluvium	Carrington
CFW55R	MB	EX	310438.96	6402179.73	70.28	0.5	16.4	9.4	16.4	-	-	50	Palaeochannel alluvium	Carrington
CFW57	MB	EX	310083.7	6402052.62	70.75	0.7	16.44	8.44	15.44	-	-	50	Palaeochannel alluvium	Carrington
CGW32	MB	EX	308598	6404872	79.18	-	-	-	-	-	-	-	Palaeochannel alluvium	Carrington
CGW52a	MB	EX	309901.62	6402249.47	71.36	0.75	18.55	-	-	-	-	50	Alluvium	Carrington
CGW53a	MB	EX	309606	6402333	70.53	0.7	14.74	-	-	-	-	50	Alluvium	Carrington
CGW54a	MB	EX	310196.21	6402158.88	70.00	0.79	17.1	-	-	-	-	50	Alluvium	Carrington
CGW55a	MB	EX	309840	6402457	71.04	0.48	18.46	-	-	-	-	50	Alluvium	Carrington
GW_101	MB	EX	304373.64	6406727.78	100.54	-	12	9	12	-	-	50	Regolith, alluvium	Carrington
GW_106	MB	AU	309091.86	6405223.99	82.26	0.84	30	24	27	-	-	50	Palaeochannel alluvium or weathered sandstone?	Carrington
CGW39	MB	EX	308566	6403694	70.17	0.53	13.45	5	14	-	-	-	Alluvium?	Carrington
CGW45	MB	EX	308042	6403349	72.51	0.33	14.44	-	-	-	-	25	Bayswater Seam	Carrington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Top of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
CGW45a	MB	AD	308044	6403349	72.65	0.47	-	-	-	-	-	65	Broonie Seam	Carrington
CGW46	MB	EX	308413	6403276	71.95	-	13.64	-	-	-	-	25	Bayswater Seam	Carrington
CGW46a	MB	EX	308415	6403276	71.95	-	-	-	-	-	-	65	Broonie Seam	Carrington
CGW47	MB	EX	308729	6403406	70.83	0.44	16.47	-	-	-	-	25	Bayswater Seam	Carrington
CGW47a	MB	EX	308731	6403405	70.83	0.44	-	-	-	-	-	50	Broonie Seam	Carrington
CGW49	MB	EX	308778	6403098	69.57	0.49	13.3	-	-	-	-	80	Bayswater Seam	Carrington
CGW52	MB	EX	309905.73	6402255.4	71.40	0.7	45.25	-	-	-	-	25	Broonie Seam	Carrington
CGW53	MB	EX	309605.51	6402332.71	70.48	0.61	43	-	-	-	-	25	Broonie Seam	Carrington
GW_103	VWP	AU	306769.16	6404610.08	103.18	-	120	-	-	-	25.5 64.5 119.5	-	Coal - undifferentiated and weathered Siltstone and coal Sandstone - mg, fresh	Carrington
GW_105	VWP	AU	308597	6405442.41	93.10		154	-	-		33 103.5 154	-	Coal - undifferentiated Coal - tuffaceous Coal	Carrington
GW_109	VWP	AU	309232.07	6402705.86	85.16	-	-	-	-		31.5 65 89.5	-	Coal - slightly weathered Coal - tuffaceous Bayswater Seam	Carrington
4036C	MB	EX	308272.36	6402687.62	71.78	1.08	35.2	33.1	34.1		-	50	Interburden (Siltstone/Sandstone)	Carrington
4051C	MB	EX	308664	6402721	69.90	0.98	31.51	31.75	32.75		-	50	Interburden (Siltstone/Sandstone)	Carrington
CGW51a	MB	EX	310148.93	6402419.17	70.21	0.17	17.18	-	-	-	-	50	Interburden (Siltstone/Sandstone)	Carrington
GW_100a	VWP	EX	303721.7	6406444.63	89.38	-	60	-	-	-	51	-	Barrett Seam and Interburden	Carrington

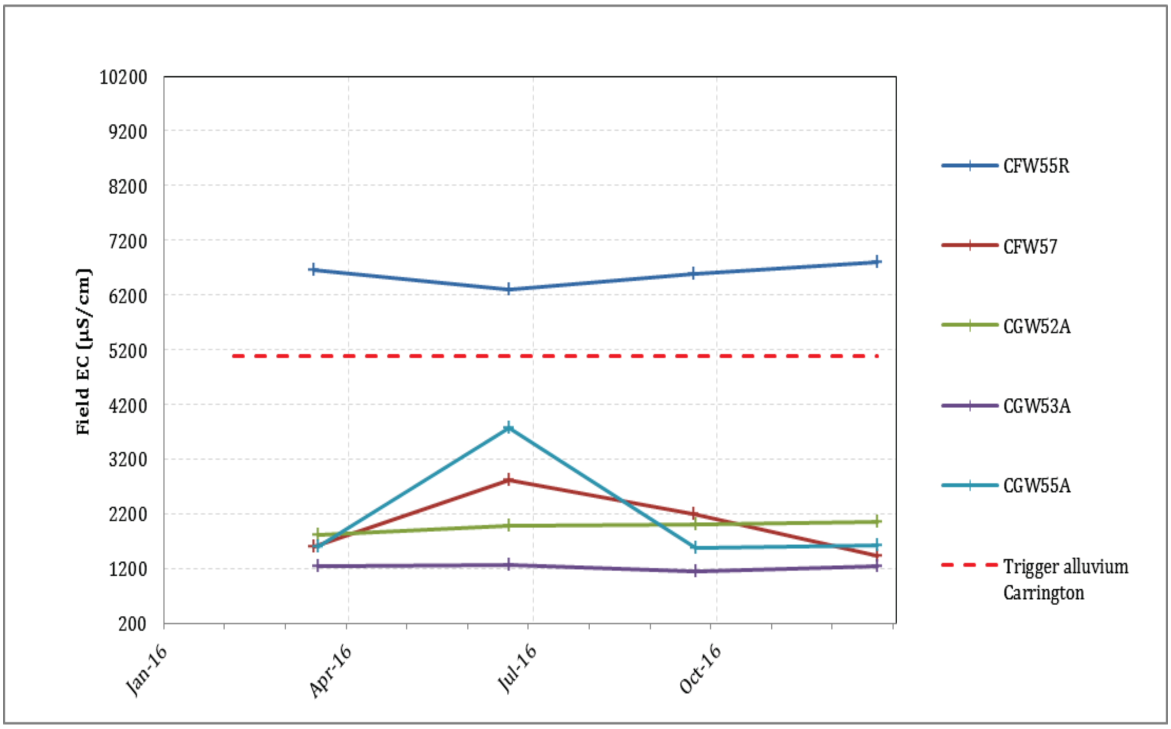
Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Top of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
GW_101a	VWP	AU	304362.4	6406720.58	100.55	-	52	-	-	-	51	-	Interburden (Siltstone/Sandstone)	Carrington
GW_102	VWP	AU	305279.82	6406667.69	114.60	-	60.5	-	-	-	60.5	-	Interburden (Sandstone with minor coal)	Carrington
GW_104	VWP	AU	307548.87	6404657.16	86.75	-	136	-	-	-	59 107 135	-	Lower Pikes Gully Seam Sandstone IB (near Upper Liddell Seam) Sandstone (above Barret)	Carrington
GW_110	VWP	AU	310502.8	6404597.56	124.64	-	-	-	-	-	38 63 93	-	Sandstone - fresh Sandstone Bayswater Seam	Carrington
GW_107	MB	EX	308737.77	6404102.81	73.47		28.63	24.2	27.2		-	50	Carrington Spoil	Carrington
GW_108	MB	EX	309695.01	6403970.7	84.39	-	61.5	52.5	58.5	-	-	50	Carrington Spoil	Carrington
GW_115	MB	EX	312227.24	6402216	68.32		28.7	22.2	28.2		-	50	Spoil	Carrington

Appendix B **Groundwater quality**

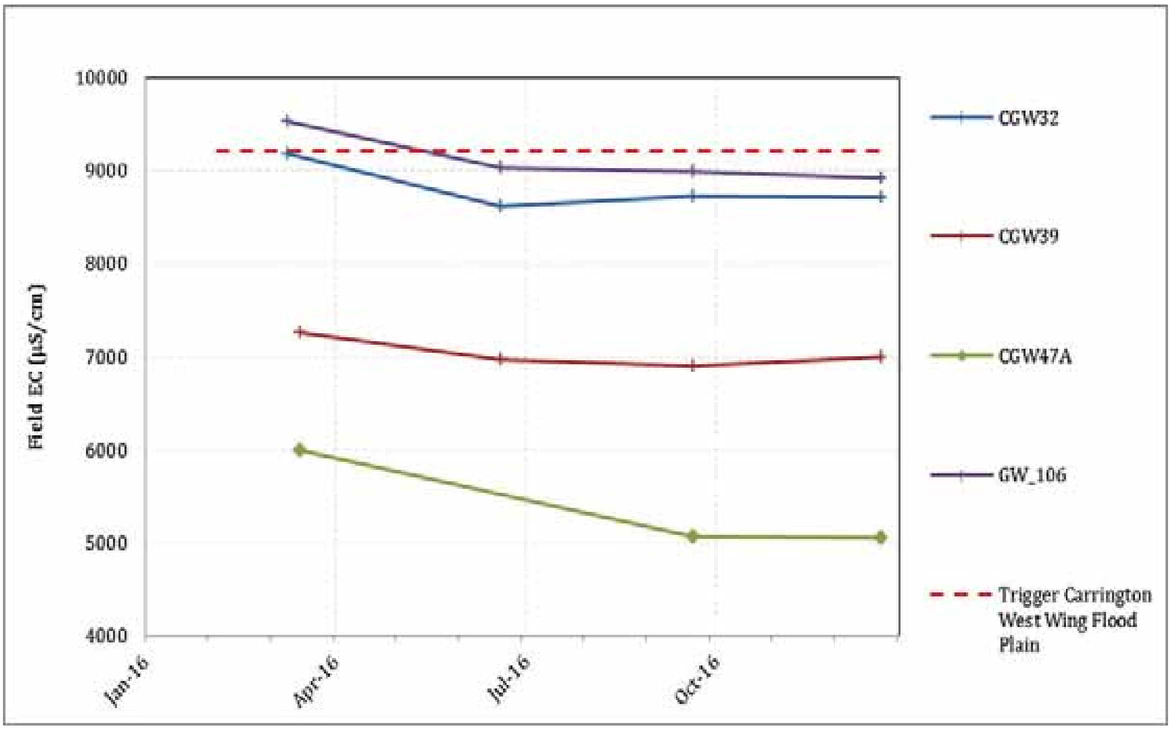
2016 Field EC



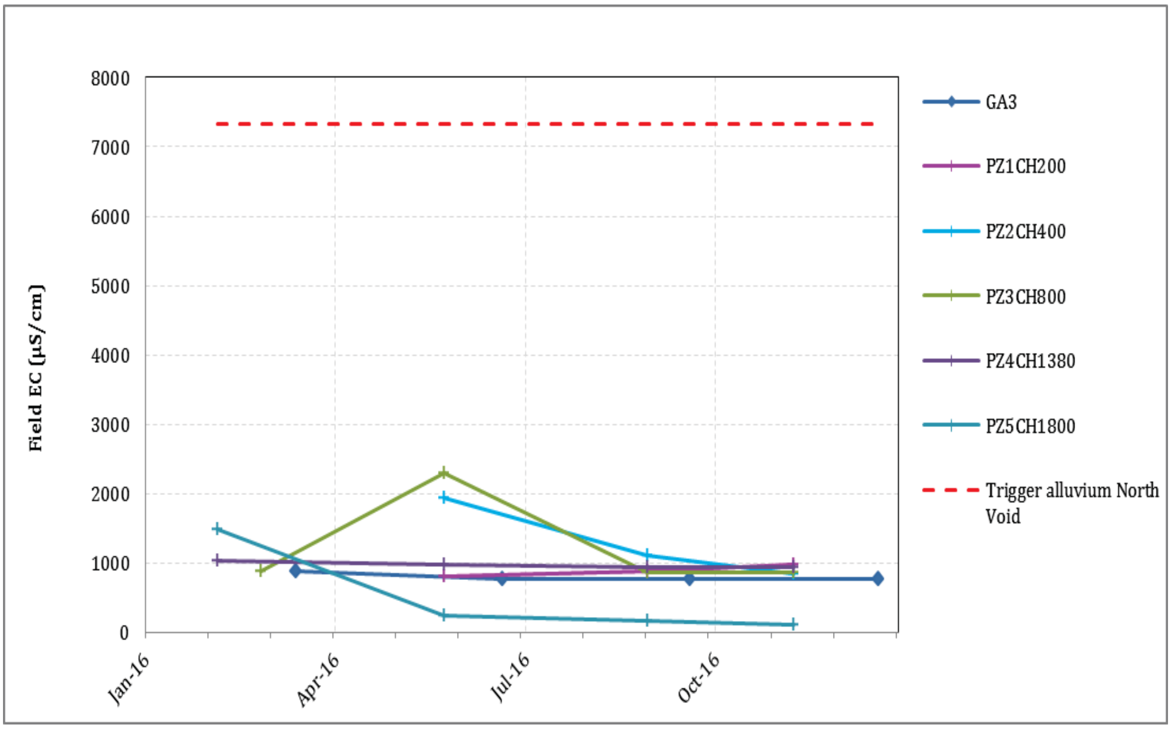
Carrington West Wing Paleochannel and Bayswater Seam



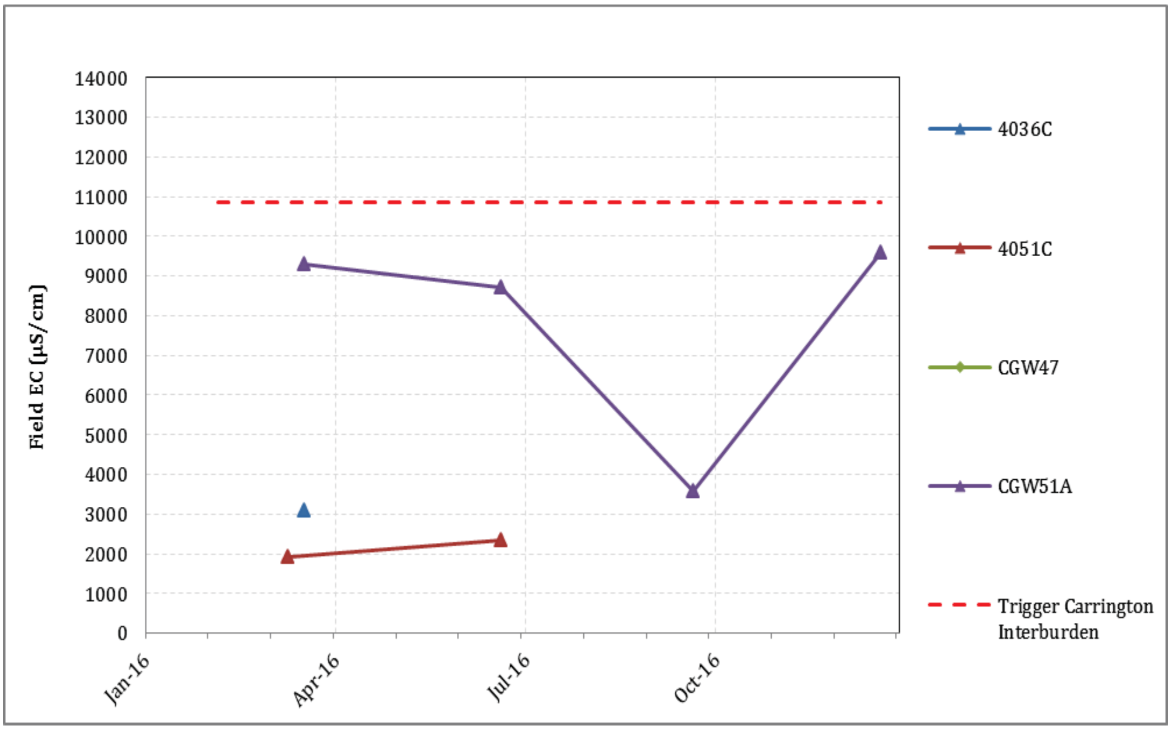
Carrington Alluvium



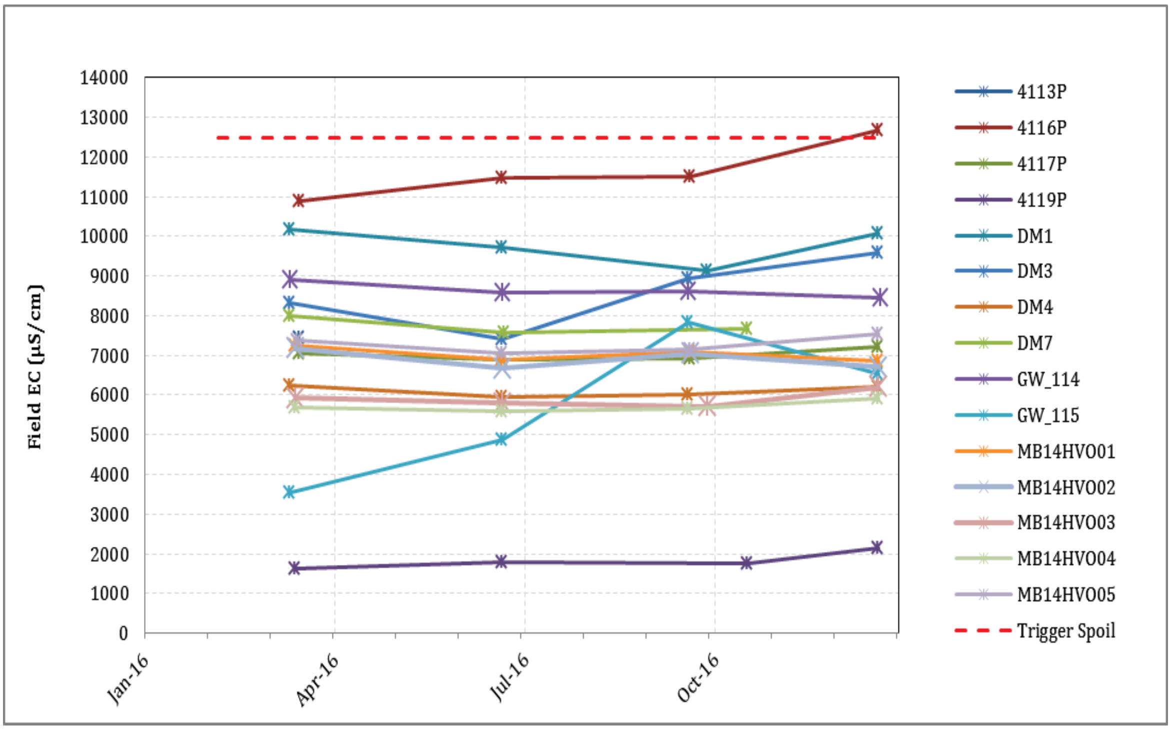
Carrington West Wing – Flood Plain



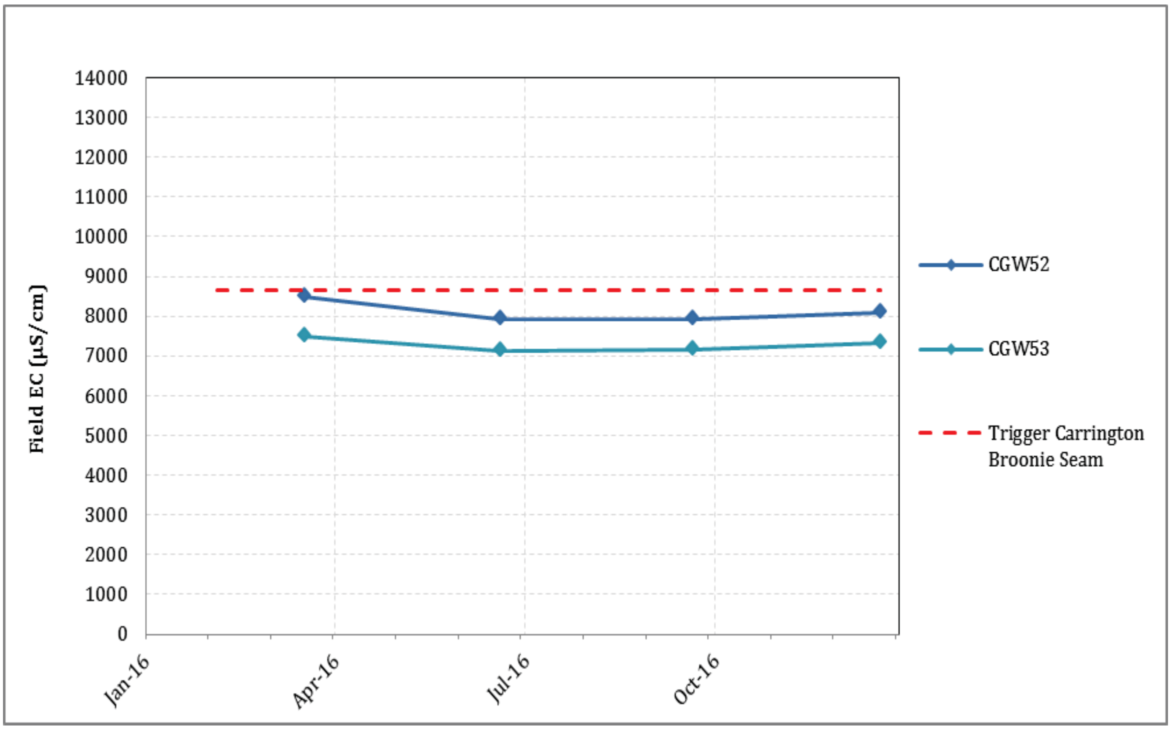
Alluvial Lands – Hunter River Alluvium



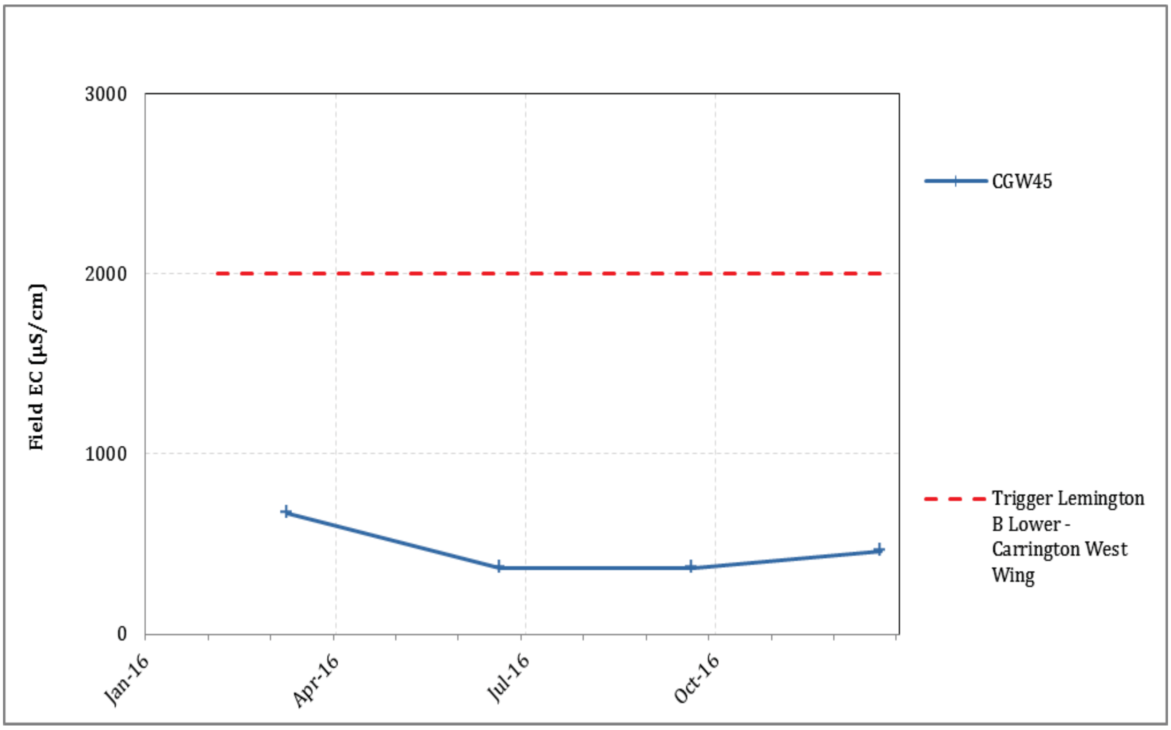
Carrington - Interburden



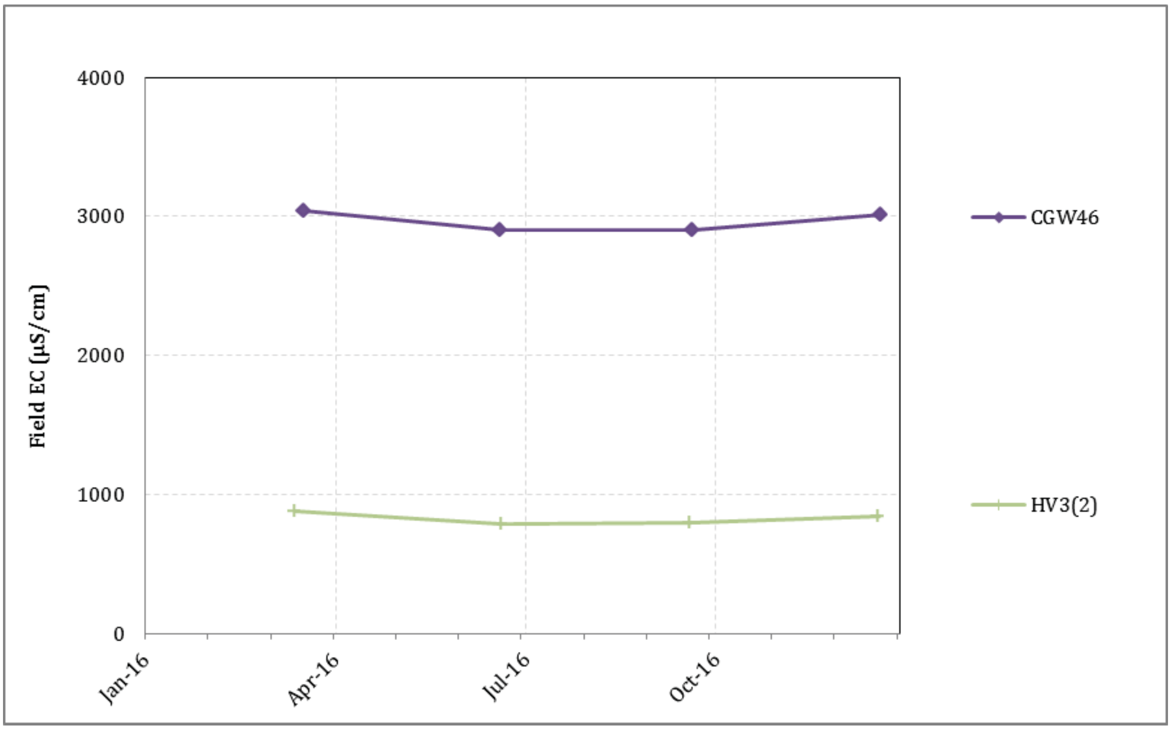
Alluvial Lands and Carrington - Spoil



Carrington – Broonie Seam

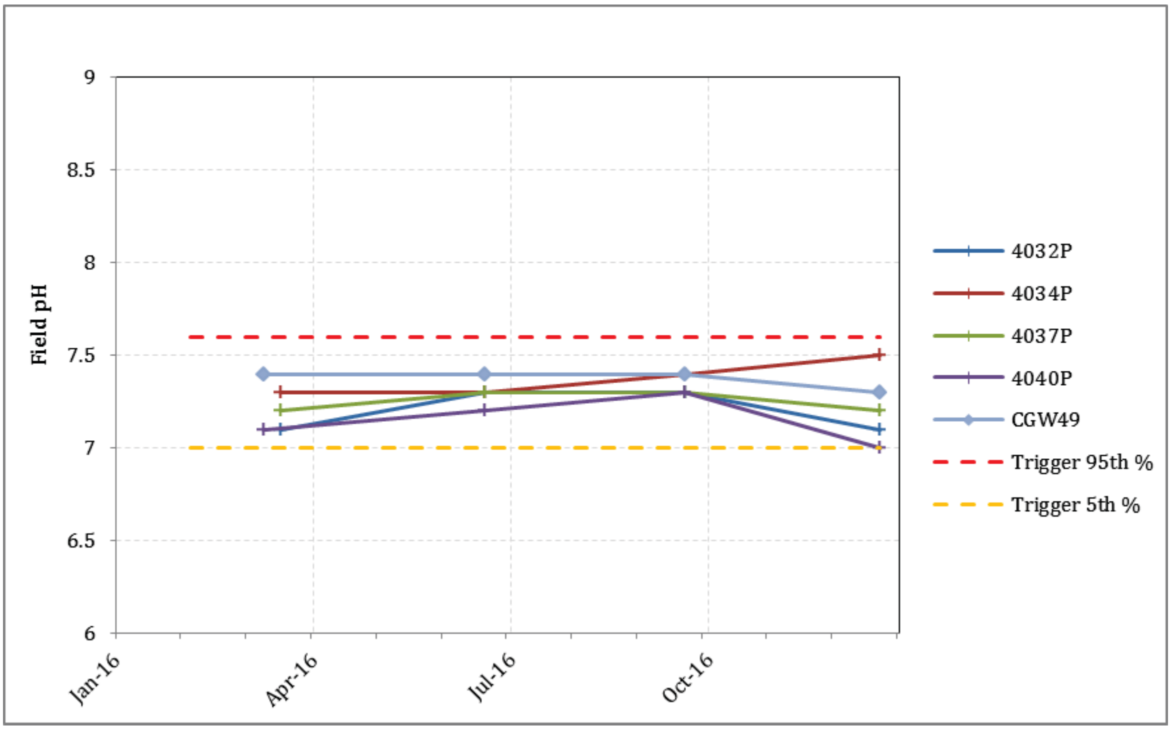


Carrington West Wing – Lemington B Lower

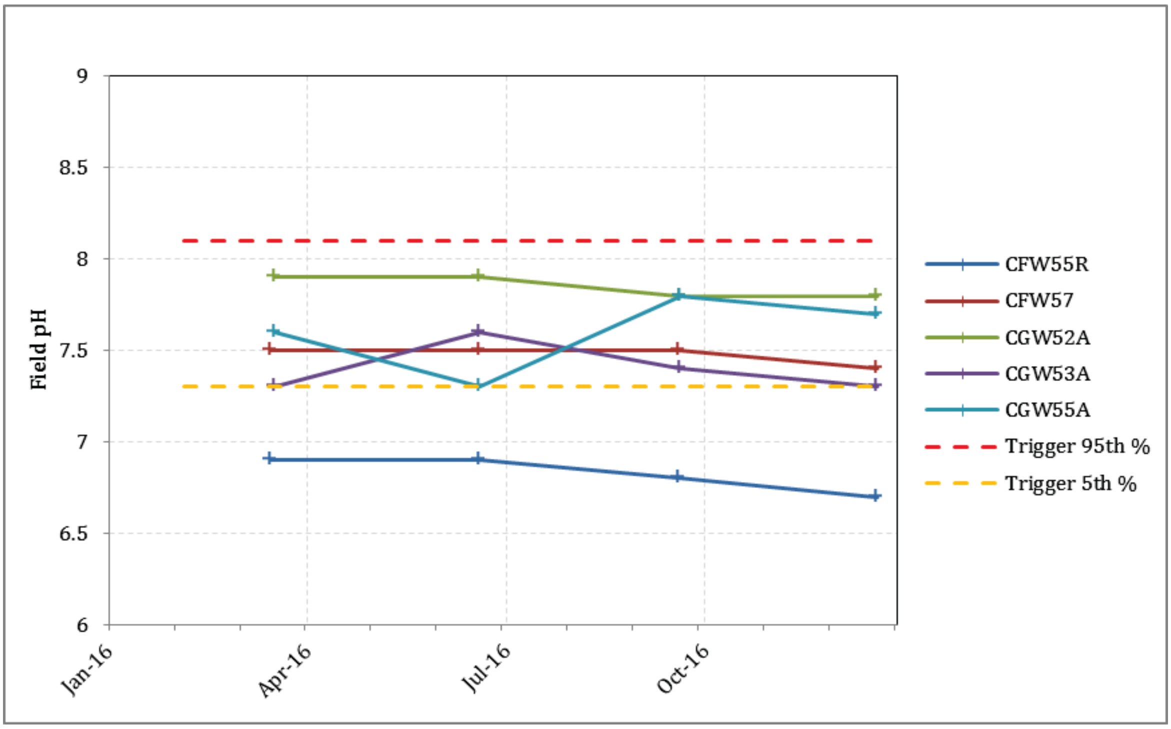


Carrington – Alluvium and Interburden (No trigger level)

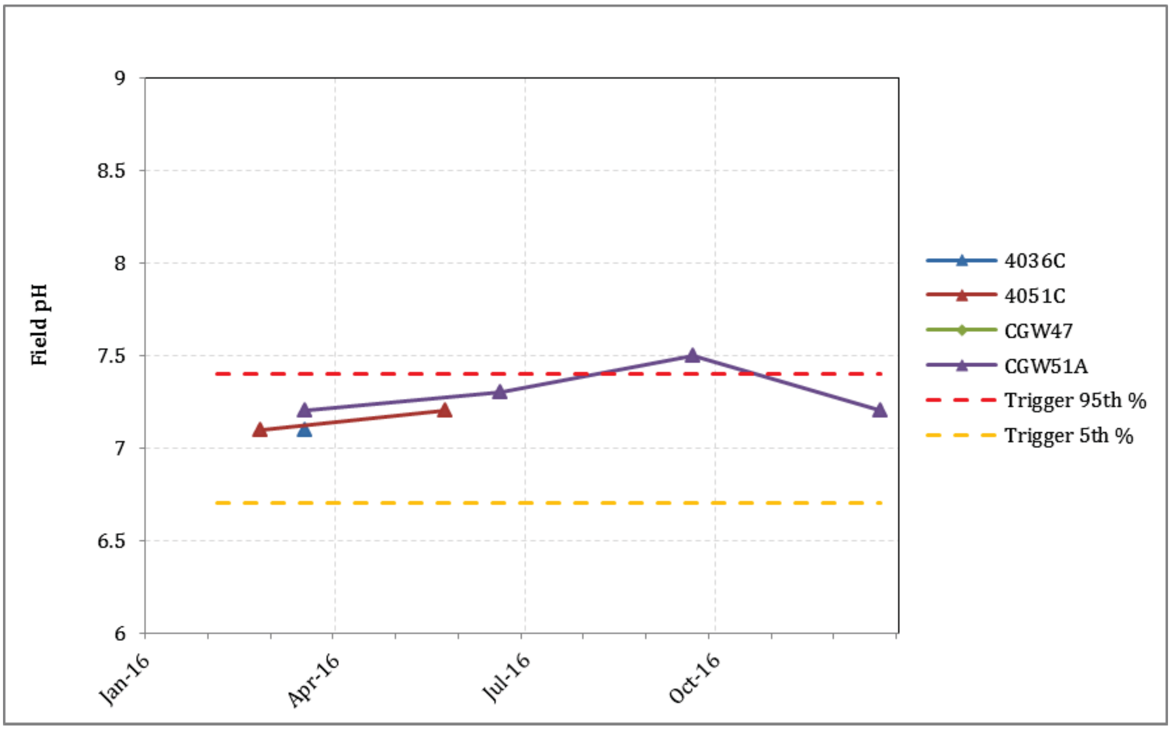
2016 Field pH



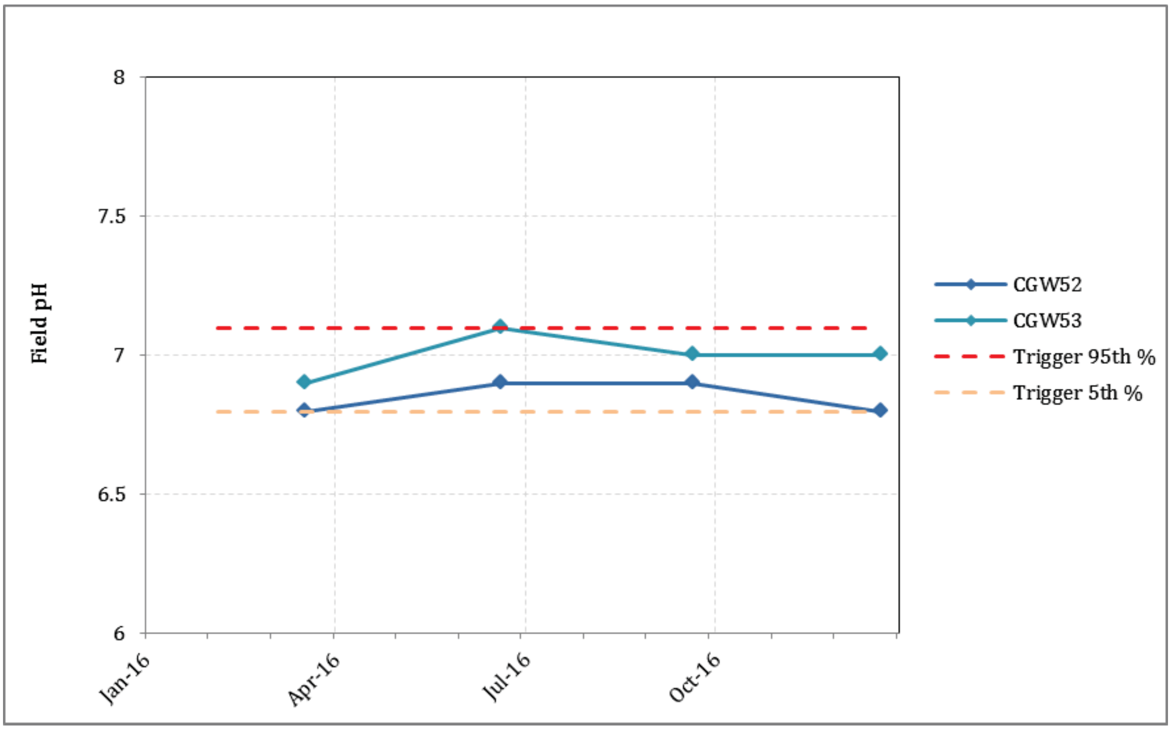
Carrington West Wing – Paleochannel and Bayswater Seam



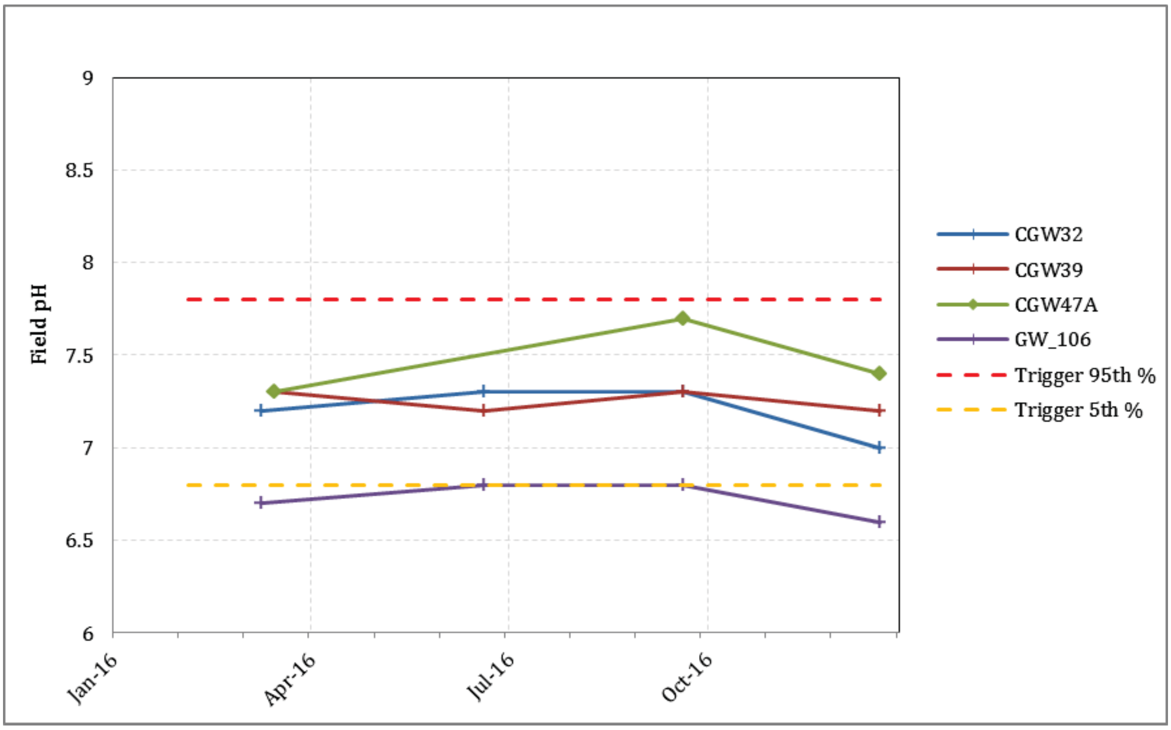
Carrington – Alluvium



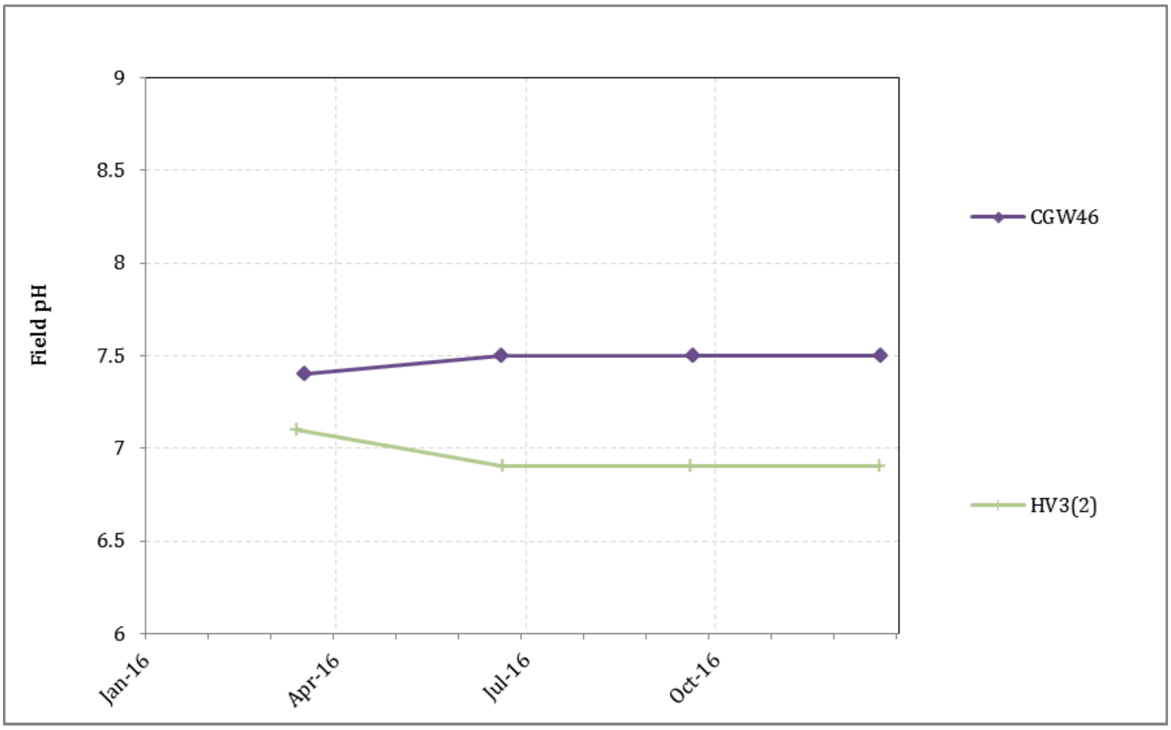
Carrington – Interburden



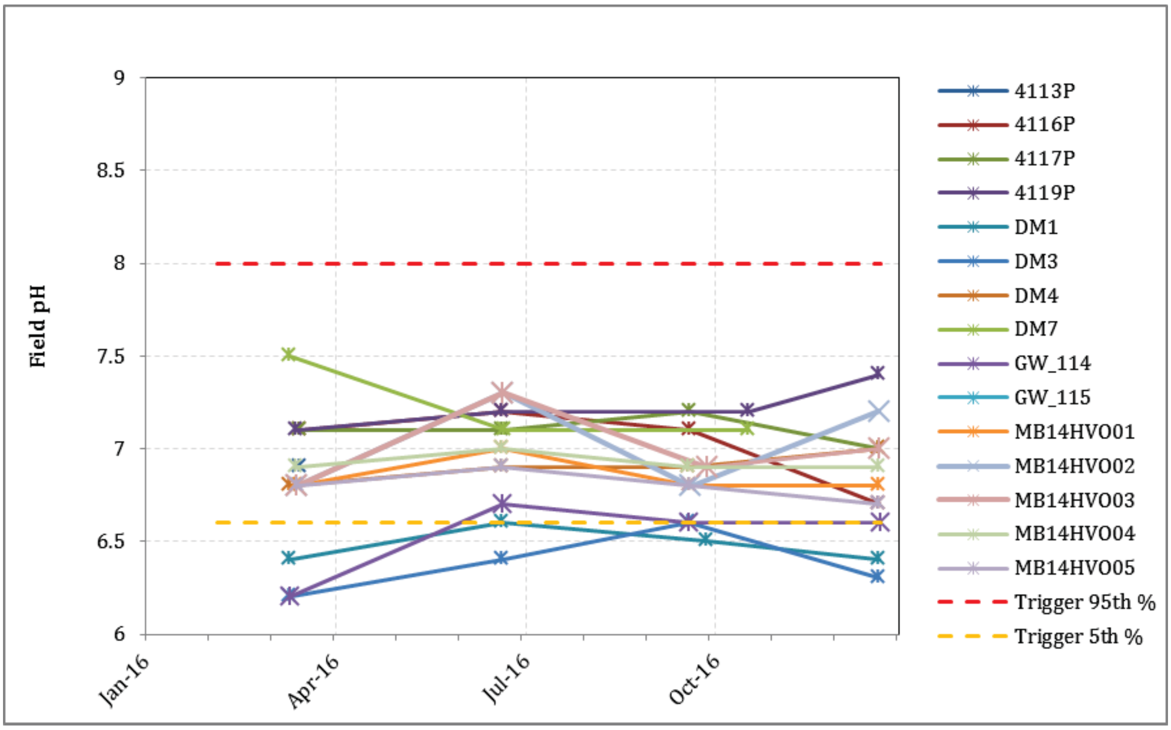
Carrington – Broonie Seam



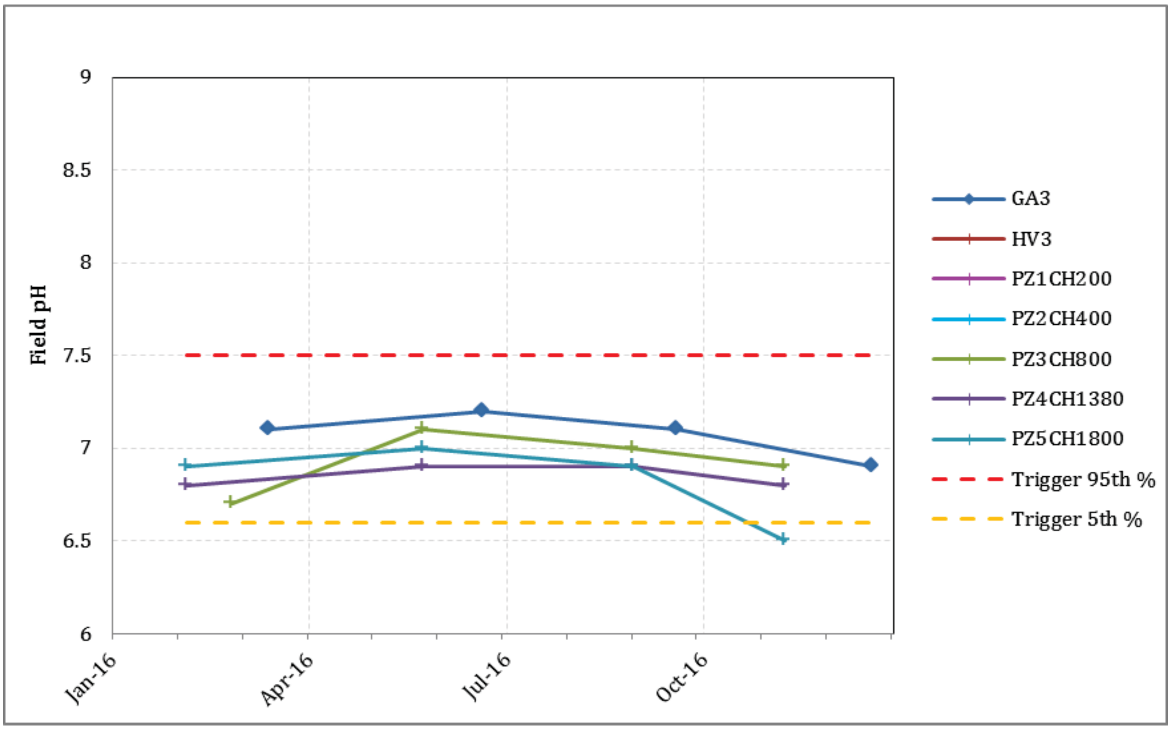
Carrington West Wing – Flood Plain



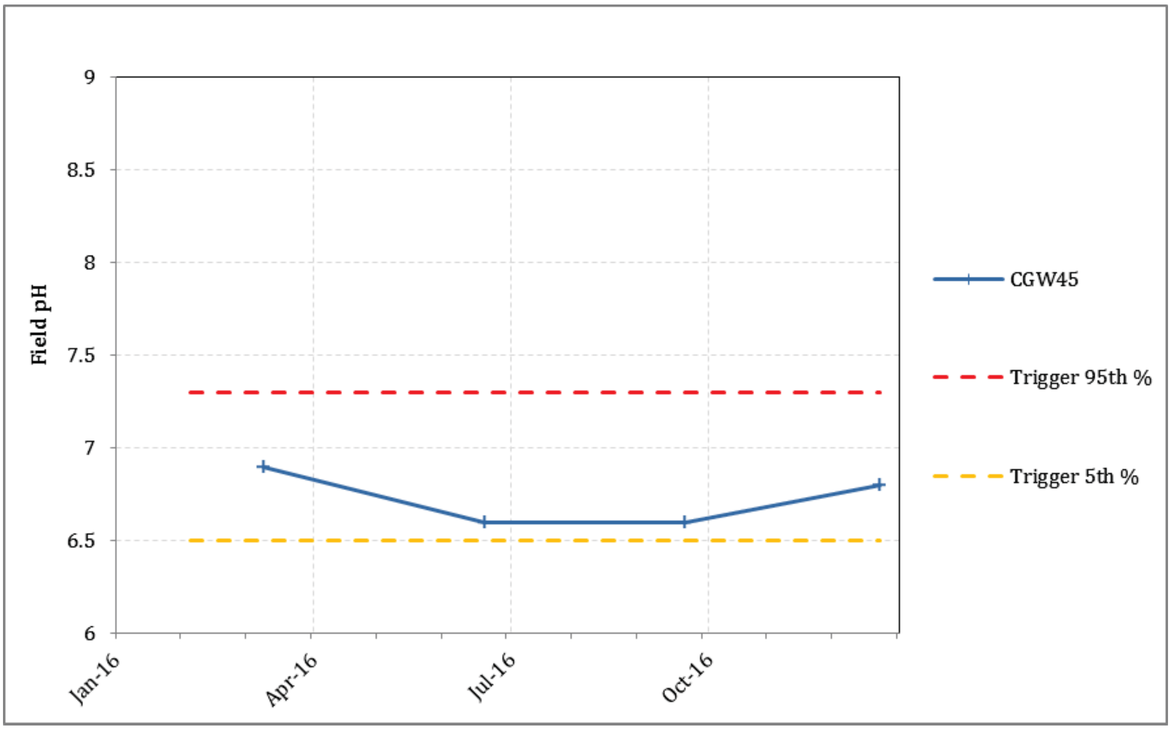
Carrington – Alluvium and Interburden (No trigger level)



Alluvial Lands and Carrington – Spoil



Alluvial Lands – Hunter River Alluvium



Carrington West Wing – Lemington B Lower

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
4032P	18/03/2016	7.1	1957	8.4	496	0.003	0.081	64		0	3.1		71		240				0.01		83		1230	0.36
4032P	21/06/2016	7.3	1800																					
4032P	22/09/2016	7.3	1746																					
4032P	22/12/2016	7.1	1672																					
4034P	18/03/2016	7.3	1334	1.9	444	0.003	0.073	60		0	2.7		81		210				0.006		82		1090	0.065
4034P	21/06/2016	7.3	1870																					
4034P	22/09/2016	7.4	1703																					
4034P	22/12/2016	7.5	1890																					
4036C	18/03/2016	7.1	3080																					
4037P	18/03/2016	7.2	1345	0.86	355	0.001	0.048	68		0	1.1		62		120				0.002		60		769	0.048
4037P	21/06/2016	7.3	1357																					
4037P	22/09/2016	7.3	1207																					
4037P	22/12/2016	7.2	1251																					
4040P	10/03/2016	7.1	1025																					
4040P	21/06/2016	7.2	1303																					
4040P	22/09/2016	7.3	844																					
4040P	22/12/2016	7	799																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
4051C	10/03/2016	7.1	1907																					
4051C	21/06/2016	7.2	2350																					
4113P	16/03/2016	6.9	7440																					
4116P	16/03/2016	7.1	10890	14	809	0.011	0.12	120		0	40		420		1600				0.005		860		7350	0.23
4117P	16/03/2016	7.1	7050	0.57	1274	0.073	0.12	110		0	28		140		1200				0.001		480		4540	0.1
4117P	22/06/2016	7.1	6880																					
4117P	21/09/2016	7.2	6920																					
4117P	21/12/2016	7	7220																					
4119P	14/03/2016	7.1	1629	0.011	480	0.058	0.072	46		0	12		34		250				0.001		150		998	0.007
4119P	22/06/2016	7.2	1782																					
4119P	20/09/2016																							
4119P	19/10/2016	7.2	1770	0.024	541	0.071	0.075	56			14		44		280				<0.001		180		1090	0.016
4119P	21/12/2016	7.4	2140																					
CFW55R	16/03/2016	6.9	6660	2.2	742	0.002	0.14	76		0	30		170		1200				0.003		1100		4730	0.018
CFW55R	21/06/2016	6.9	6310																					
CFW55R	21/09/2016	6.8	6590																					
CFW55R	22/12/2016	6.7	6790																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CFW57	16/03/2016	7.5	1588	1.1	357	0.002	0.074	14		0	1.9		21		270				0.001		59		887	0.007
CFW57	21/06/2016	7.5	2820																					
CFW57	21/09/2016	7.5	2200																					
CFW57	22/12/2016	7.4	1434																					
CGW32	10/03/2016	7.2	9190																					
CGW32	21/06/2016	7.3	8620																					
CGW32	22/09/2016	7.3	8730																					
CGW32	22/12/2016	7	8720																					
CGW39	16/03/2016	7.3	7260	3.9	846	0.005	0.079	150		0	10		250		1100				0.012		300		4520	0.037
CGW39	21/06/2016	7.2	6970																					
CGW39	22/09/2016	7.3	6900																					
CGW39	22/12/2016	7.2	7000																					
CGW45	10/03/2016	6.9	670																					
CGW45	21/06/2016	6.6	366																					
CGW45	22/09/2016	6.6	367																					
CGW45	22/12/2016	6.8	457																					
CGW46	18/03/2016	7.4	3040	22	829	0.005	0.11	65		0	11		86		440				0.01		110		1800	0.33

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CGW46	21/06/2016	7.5	2900																					
CGW46	22/09/2016	7.5	2900																					
CGW46	22/12/2016	7.5	3010																					
CGW47A	16/03/2016	7.3	6000																					
CGW47A	21/06/2016																							
CGW47A	22/09/2016	7.7	5070																					
CGW47A	22/12/2016	7.4	5050																					
CGW49	10/03/2016	7.4	2060																					
CGW49	21/06/2016	7.4	2880																					
CGW49	22/09/2016	7.4	2720																					
CGW49	22/12/2016	7.3	2610																					
CGW51A	18/03/2016	7.2	9300																					
CGW51A	21/06/2016	7.3	8700																					
CGW51A	22/09/2016	7.5	3570																					
CGW51A	22/12/2016	7.2	9600																					
CGW52	18/03/2016	6.8	8500																					
CGW52	21/06/2016	6.9	7920																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CGW52	22/09/2016	6.9	7910																					
CGW52	22/12/2016	6.8	8100																					
CGW52A	18/03/2016	7.9	1812																					
CGW52A	21/06/2016	7.9	1980																					
CGW52A	22/09/2016	7.8	2010																					
CGW52A	22/12/2016	7.8	2050																					
CGW53	18/03/2016	6.9	7500																					
CGW53	21/06/2016	7.1	7110																					
CGW53	22/09/2016	7	7150																					
CGW53	22/12/2016	7	7340																					
CGW53A	18/03/2016	7.3	1230																					
CGW53A	21/06/2016	7.6	1276																					
CGW53A	22/09/2016	7.4	1136																					
CGW53A	22/12/2016	7.3	1232																					
CGW55A	18/03/2016	7.6	1594																					
CGW55A	21/06/2016	7.3	3780																					
CGW55A	22/09/2016	7.8	1577																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CGW55A	22/12/2016	7.7	1624																					
DM1	11/03/2016	6.4	10160		825					0														
DM1	22/06/2016	6.6	9710		834																			
DM1	29/09/2016	6.5	9140																					
DM1	21/12/2016	6.4	10080		831					0														
DM3	11/03/2016	6.2	8310		713					0														
DM3	22/06/2016	6.4	7410		768																			
DM3	20/09/2016	6.6	8940																					
DM3	21/12/2016	6.3	9600		806					0														
DM4	11/03/2016	6.8	6240		909					0														
DM4	22/06/2016	6.9	5960		926																			
DM4	20/09/2016	6.9	6000																					
DM4	21/12/2016	7	6210		863					0														
DM7	11/03/2016	7.5	8010		540					0														
DM7	23/06/2016	7.1	7570		589																			
DM7	19/10/2016	7.1	7670	0.061	694	<0.001	0.093	120			51		320		1300				<0.001		1200		5520	0.01
GA3	14/03/2016	7.1	875																					
GA3	22/06/2016	7.2	760																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
GA3	21/09/2016	7.1	763																					
GA3	21/12/2016	6.9	769																					
GW-106	10/03/2016	6.7	9540																					
GW-106	21/06/2016	6.8	9030																					
GW-106	22/09/2016	6.8	8990																					
GW-106	22/12/2016	6.6	8920																					
GW-114	11/03/2016	6.2	8900																					
GW-114	22/06/2016	6.7	8590																					
GW-114	20/09/2016	6.6	8630																					
GW-114	22/12/2016	6.6	8440																					
GW-115	11/03/2016	7	3560																					
GW-115	22/06/2016	7.2	4890																					
GW-115	20/09/2016	6.8	7830																					
GW-115	21/12/2016	7.1	6550																					
HV3(2)	14/03/2016	7.1	883																					
HV3(2)	22/06/2016	6.9	790																					
HV3(2)	21/09/2016	6.9	795																					
HV3(2)	21/12/2016	6.9	843																					
MB14HVO01	14/03/2016	6.8	7240	0.006	861	0.066	0.14	190		0	35		210		1000				0.001		1200		4930	0.009
MB14HVO01	22/06/2016	7	6900																					
MB14HVO01	21/09/2016	6.8	7090																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered	Hydroxide Alk	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
MB14HVO01	21/12/2016	6.8	6860																					
MB14HVO02	14/03/2016	6.8	7180	0.005	736	0.14	0.12	190		0	34		250		1200				0.001		1200		4890	0.012
MB14HVO02	22/06/2016	7.3	6670																					
MB14HVO02	21/09/2016	6.8	7050																					
MB14HVO02	21/12/2016	7.2	6710																					
MB14HVO03	14/03/2016	6.8	5930	0.007	795	0.13	0.13	180		0	31		180		840				0.001		1000		4110	0.005
MB14HVO03	22/06/2016	7.3	5800																					
MB14HVO03	29/09/2016	6.9	5720																					
MB14HVO03	21/12/2016	7	6210																					
MB14HVO04	14/03/2016	6.9	5700	0.73	739	0.093	0.12	260		0	30		210		800				0.001		1200		4080	0.022
MB14HVO04	22/06/2016	7	5600																					
MB14HVO04	20/09/2016	6.9	5660																					
MB14HVO04	21/12/2016	6.9	5930																					
MB14HVO05	15/03/2016	6.8	7380	0.006	706	0.015	0.12	180		0	35		300		1100				0.001		1400		5320	0.005
MB14HVO05	22/06/2016	6.9	7060																					
MB14HVO05	21/09/2016	6.8	7140																					
MB14HVO05	21/12/2016	6.7	7540																					
PZ1CH200	5/02/2016	7	561																					
PZ1CH200	25/05/2016	7.2	812																					
PZ1CH200	31/08/2016	7.1	875																					
PZ1CH200	10/11/2016	7.1	980																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/l)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
PZ2CH400	26/02/2016	6.6	1420																					
PZ2CH400	25/05/2016	7.1	1940																					
PZ2CH400	31/08/2016	7	1101	0.1	364	0.001	0.037	83	6		4.8	0.005	38	310	63	16	1.6	0.003	0.001	31	56	720	654	0.01
PZ2CH400	10/11/2016	6.8	852																					
PZ3CH800	26/02/2016	6.7	879																					
PZ3CH800	25/05/2016	7.1	2290																					
PZ3CH800	31/08/2016	7	868	0.13	315	0.001	0.031	73	49		2.1	0.005	41	42	47	0.59	0.34	0.003	0.001	33	43	570	457	0.013
PZ3CH800	10/11/2016	6.9	858																					
PZ4CH1380	5/02/2016	6.8	1030																					
PZ4CH1380	25/05/2016	6.9	978																					
PZ4CH1380	31/08/2016	6.9	931																					
PZ4CH1380	10/11/2016	6.8	938																					
PZ5CH1800	5/02/2016	6.9	1479																					
PZ5CH1800	25/05/2016	7	249																					
PZ5CH1800	31/08/2016	6.9	166																					
PZ5CH1800	10/11/2016	6.5	117																					

Appendix C   Hydrographs

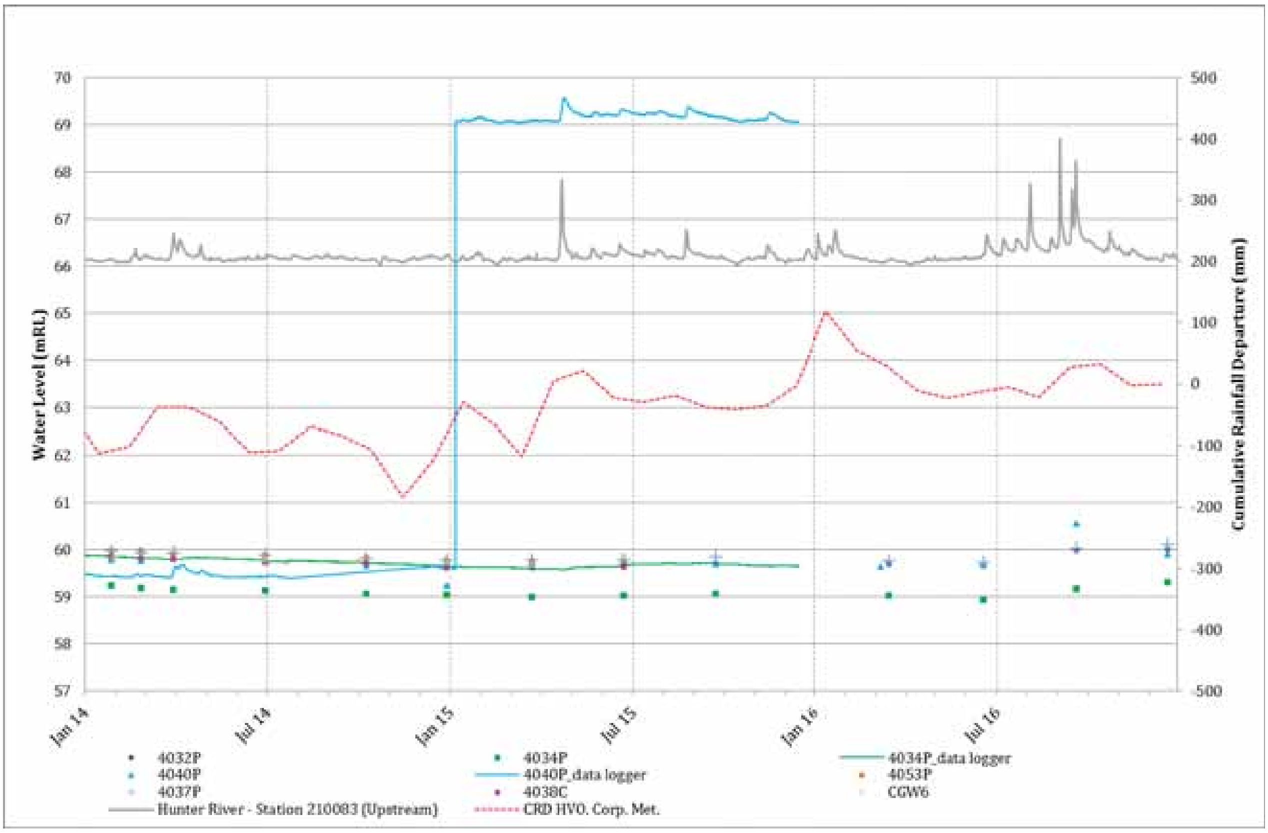


Figure C.1 Carrington West Wing – Paleochannel – within 700 m of Hunter River

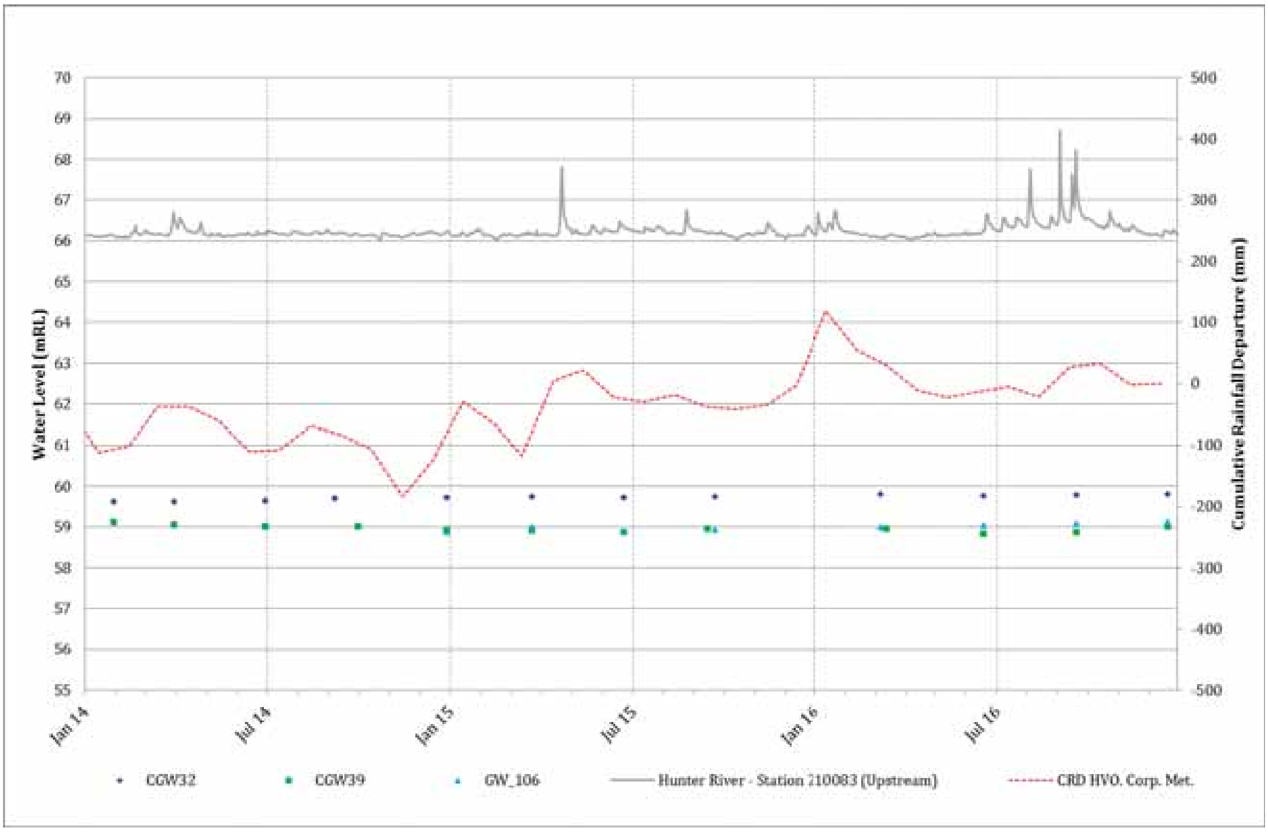


Figure C.2 Carrington West Wing – Paleochannel – over 700 m from Hunter River

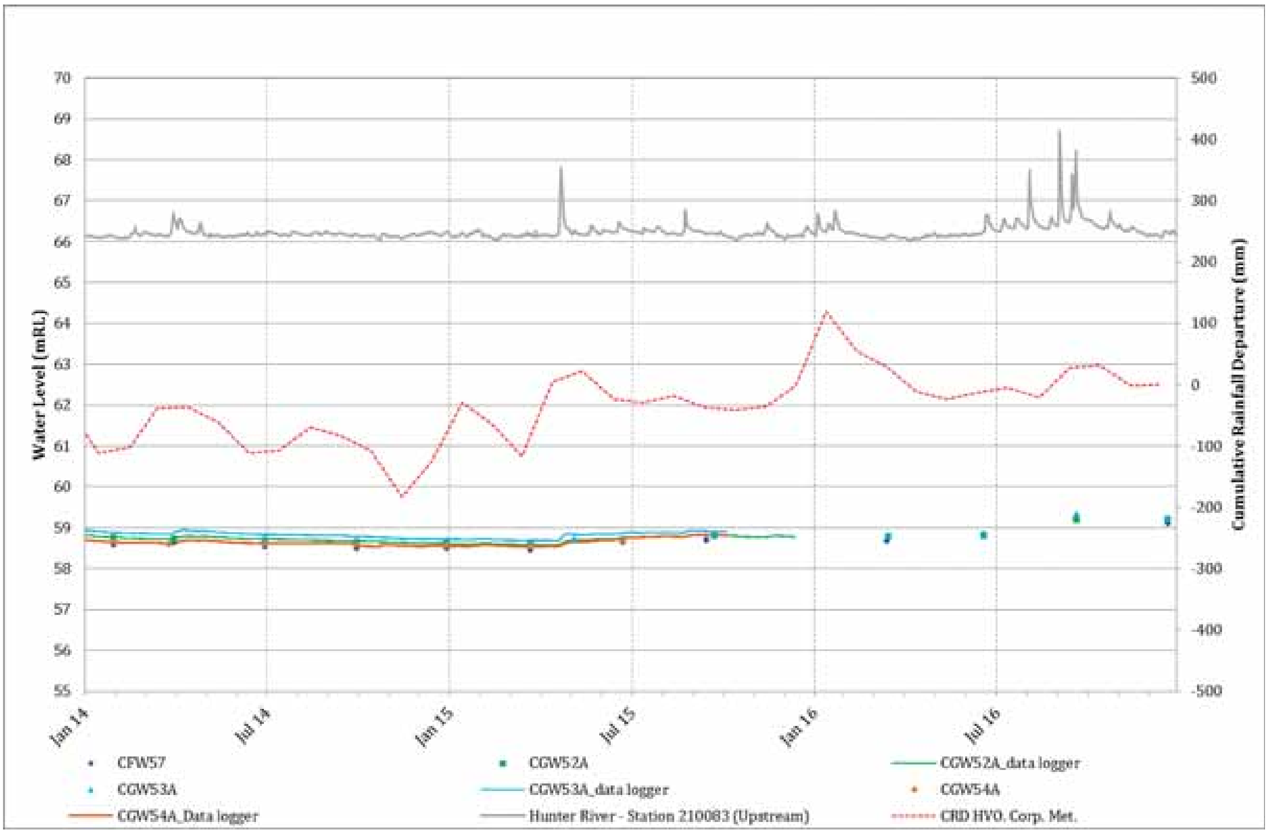


Figure C.3 Carrington East Wing – Palaeochannel – within 250 m of Hunter River

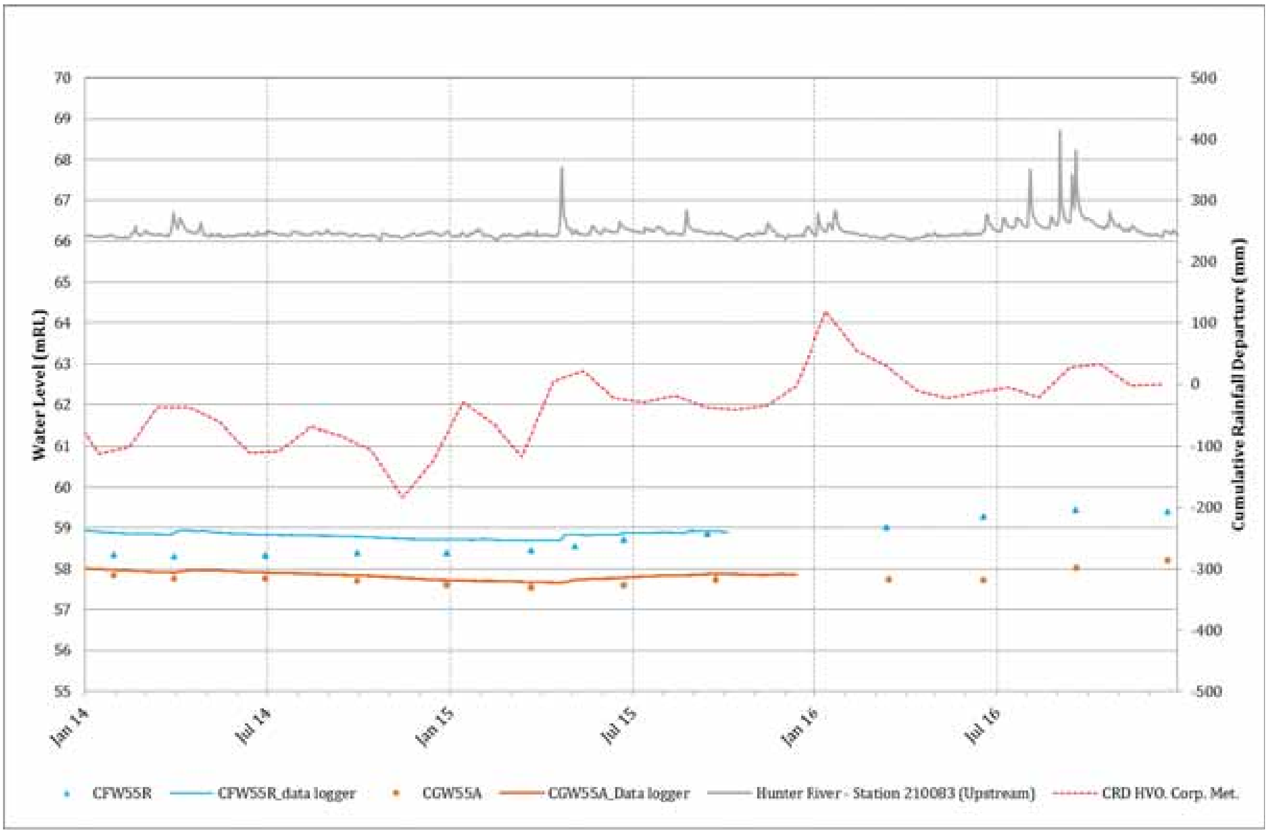


Figure C.4 Carrington East Wing – Paleochannel – over 250 m from Hunter River

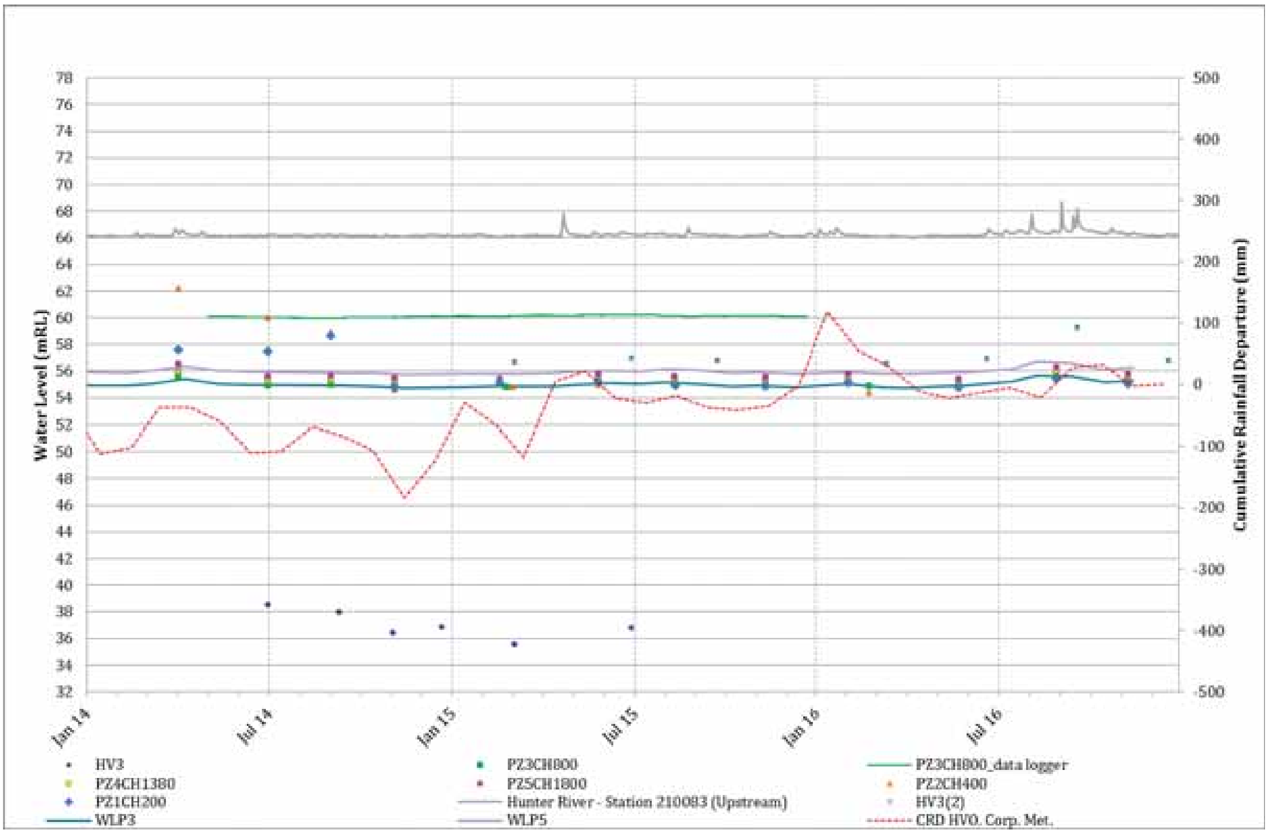


Figure C.5 Hunter River Alluvium

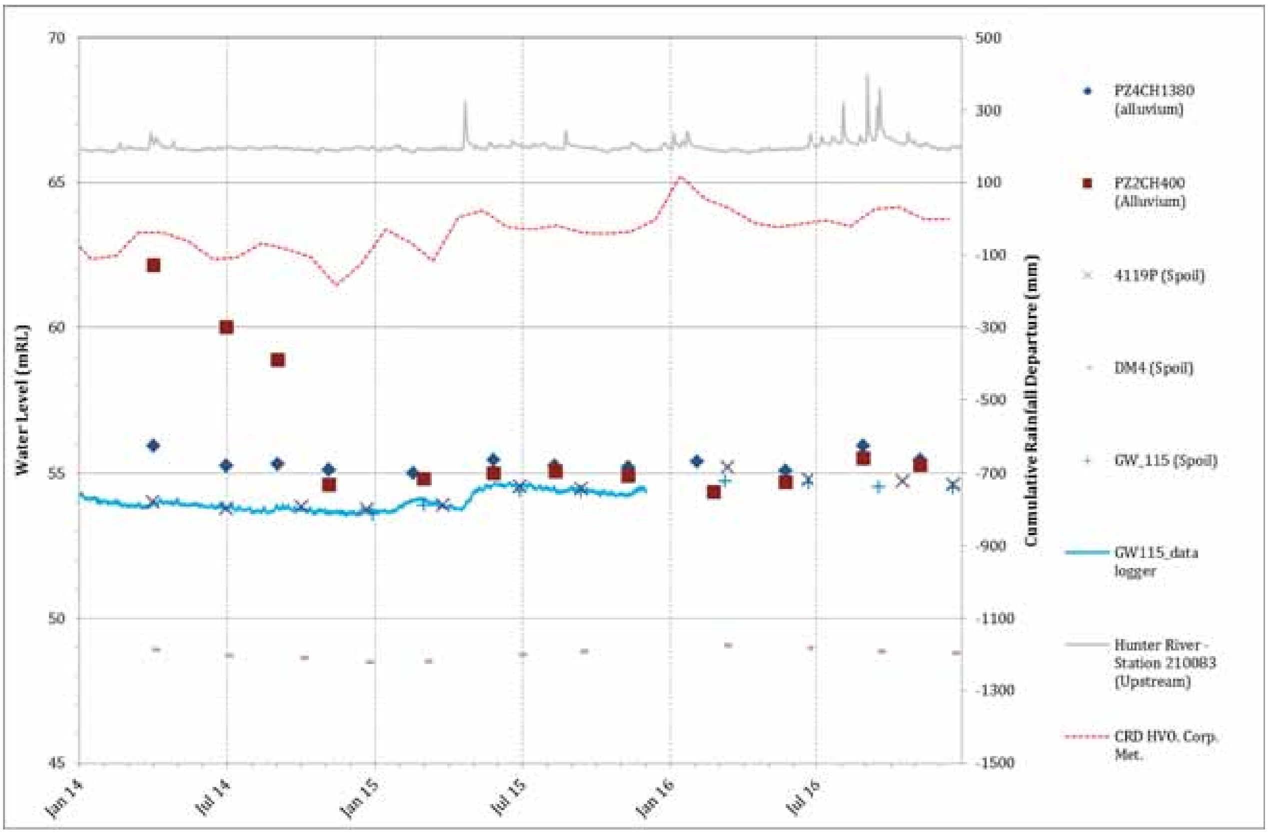
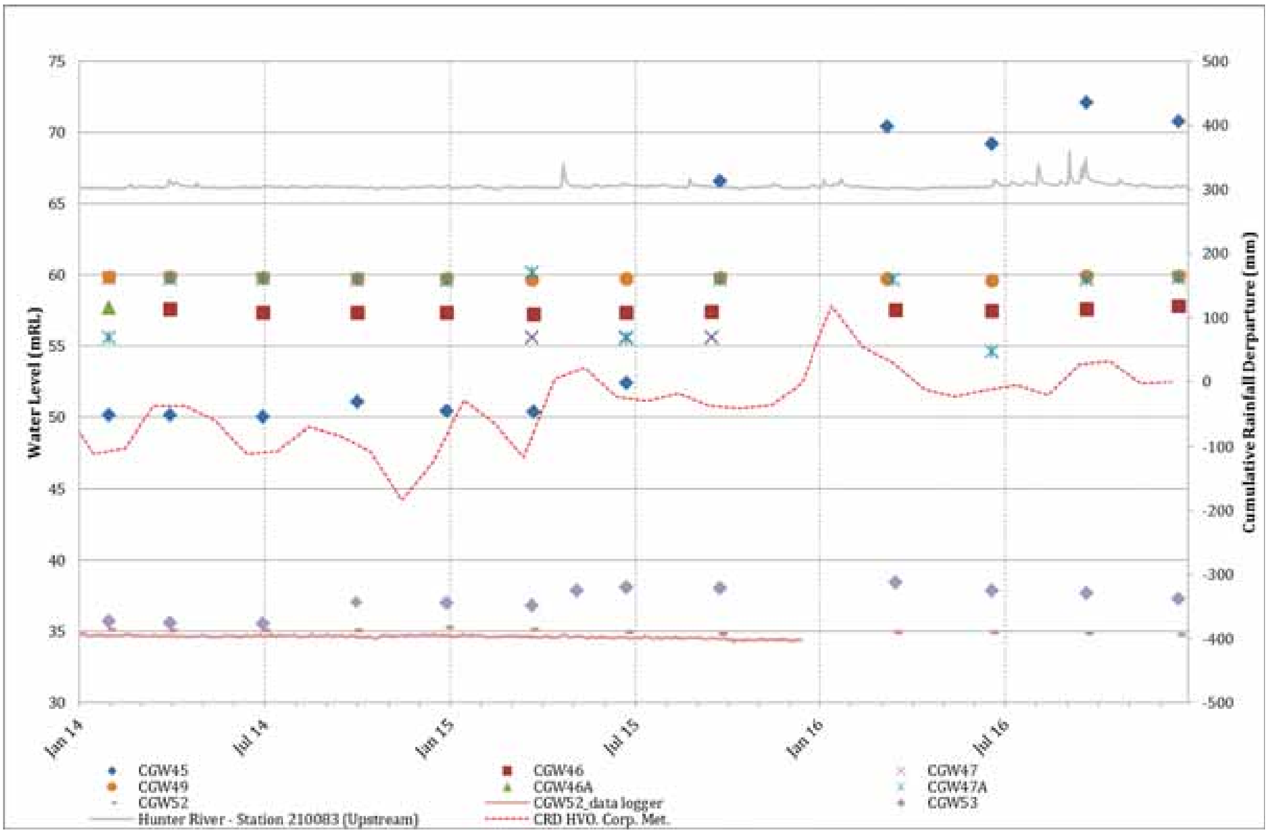


Figure C.6 Alluvial Lands / East Wall – Spoil and Alluvium



FigureC.7 Permian Coal Seams

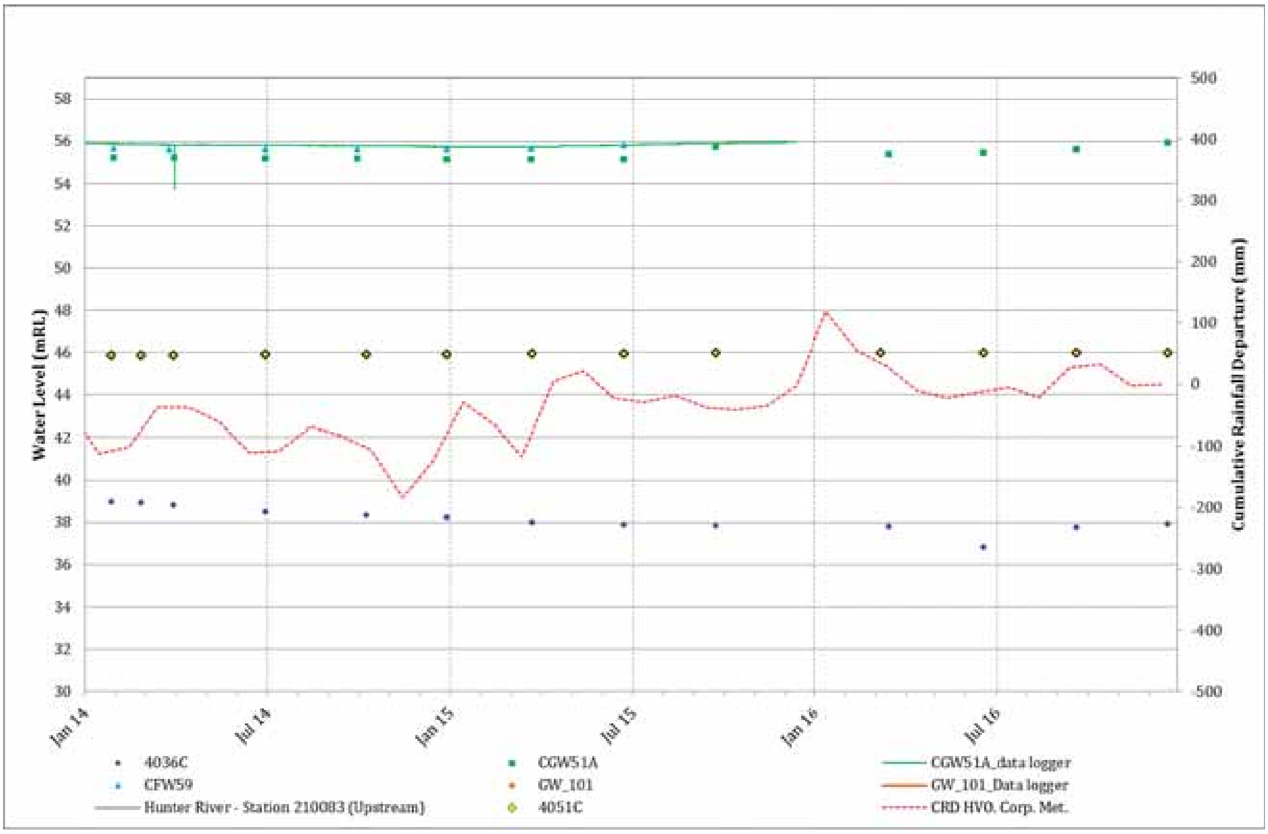


Figure C.8 Permian Interburden and Alluvium / Regolith

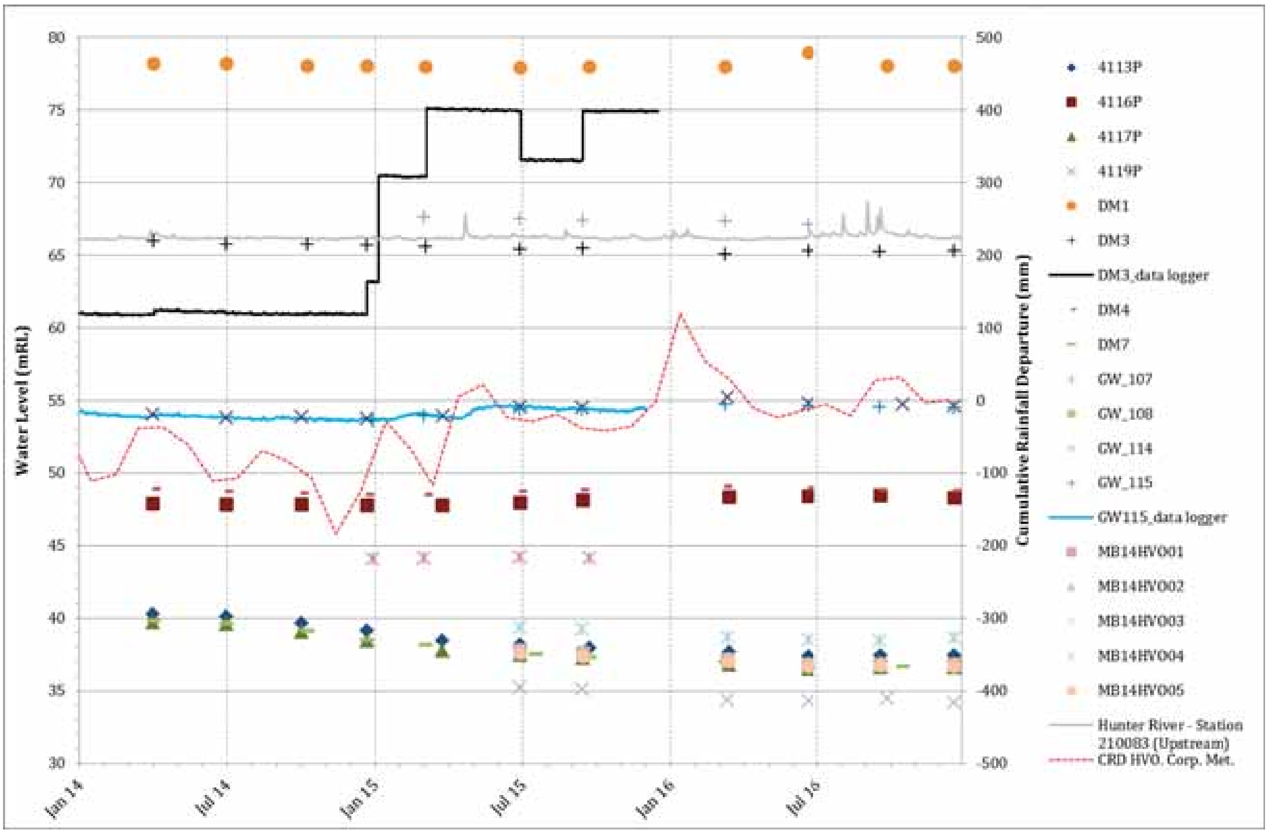


Figure C.9 Spoil

Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

HVO South and Lemington
2016 Annual Review

Prepared for
Coal and Allied Operations Pty Ltd

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Australasian Groundwater and Environmental Consultants Pty Ltd

AGE Head Office
Level 2 / 15 Mallon Street,
Bowen Hills, QLD 4006, Australia
T. +61 7 3257 2055
F. +61 7 3257 2088
brisbane@ageconsultants.com.au

AGE Newcastle Office
4 Hudson Street,
Hamilton, NSW 2303, Australia
T. +61 2 4962 2091
F. +61 2 4962 2096
newcastle@ageconsultants.com.au

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Report on

HVO South and Lemington
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1 Introduction

The Hunter Valley Operations (HVO) mining complex is located approximately 20 km north-west of Singleton, NSW. The Hunter River runs through HVO dividing it into two separate mining areas known as HVO North and HVO South (Figure 2.1).This report focuses on HVO South (the Project area), located south of the Hunter River.

HVO is owned by Rio Tinto Coal Australia (RTCA) and operated by Coal and Allied Operations Pty Ltd (Coal & Allied). Coal & Allied commissioned Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to review the impacts of mining on groundwater systems within the Project area for the 2016 calendar year. The annual review included:

- preparation of water quality tables and graphs;
- assessment of compliance with trigger values adopted in the site Water Management Plan (WMP);
- preparation of water table and piezometric contours from monitoring data pertaining to the Project area;
- assessment of alluvial sediments and Permian strata groundwater flows over the 2016 monitoring period; and
- estimation of groundwater take from the Hunter River Alluvium.

The report addresses the Special Environmental Conditions in Schedule 3 of the Project Approval, issued by the Minister for Planning (Rio Tinto, 2009) which require an annual review of groundwater monitoring data, and for Condition 28 assessment of:

- "*alluvial and hard rock buffer groundwater levels;*
- *interpreted drawdown levels resulting from existing and/or ongoing mining operations of the project;* and
- *accounting for any drawdown loss of alluvial groundwater or river flows*."

Furthermore, this report presents the assessment of existing consent comittments for Lemington Underground (LUG) Bore 20BL17392 (superceded by WAL39798), specifically conditions 13 and 14. The majority of the requirements are assessed as part of the annual review; however, there are several additionnal assessment criteria for the LUG Bore, including:

- *"review actual impacts of the extractions on any aquifers, groundwater dependant ecosystems and streams in the area";*
- *"make comparisons between actual and predicted impacts (modelled results)";*
- *"provide statistics for the monitoring data collated for each bore for the previous year"; and*
- *"assess compliance with the licence terms and conditions".*

2 Project setting

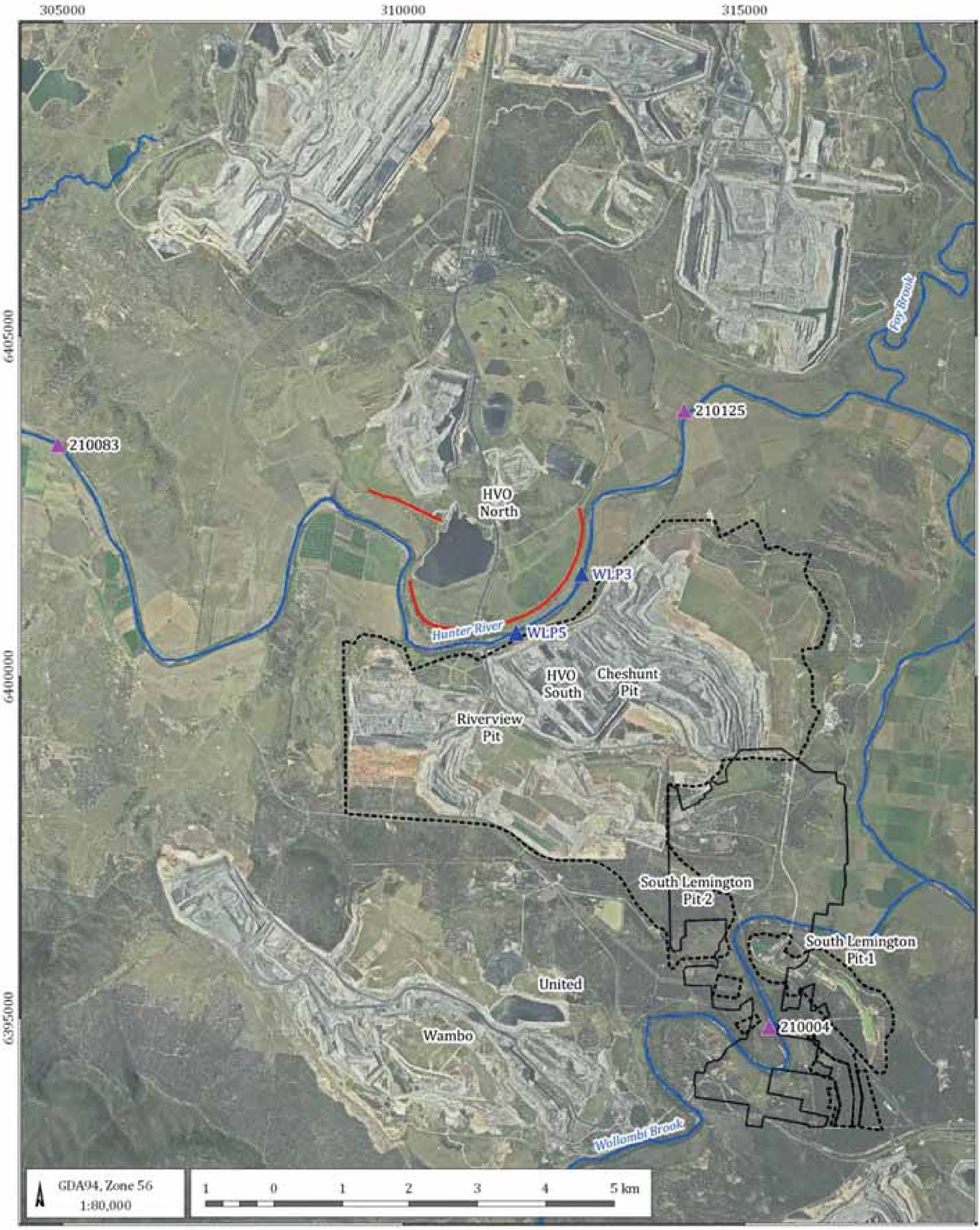
2.1 Location and mining

This report focuses on HVO South, which is located to the south of the Hunter River and comprises three main mining areas namely the Cheshunt Pit, Riverview Pit and the inactive South Lemington Pit 1. HVO South is bound by the Golden Highway to the west and the New England Highway to the east. Several mines are located around HVO South, including Wambo Mine and United Mine, which are located to the south.

HVO South generates thermal and semi-soft coking coal for the local and export market. Open cut mining at HVO South is conducted using a dragline and truck and shovel method. Mining commenced operations in 1997 and is currently approved until 23 March 2030 (Table 2.1). The location of the various mine areas are shown on Figure 2.1 and details about the HVO South and HVO North pits are included in Table 2.1. It should be noted at the time of writing Coal & Allied have submitted an application to deepen the existing mining areas. AGE (2017) prepared a groundwater impact assessment as part of this application, and information from this report is utilised in Section 6.

Table 2.1 Summary of approved mine workings and target seams

Reference name	Mine area	Basal coal seam	Start date	End date
HVO South	Cheshunt Pit (open cut)	Bayswater	2002	2028
	Cheshunt Pit north-eastern section (open cut)	Vaux	2002	2014
	Riverview Pit (open cut)	Vaux	1997	2028
	South Lemington Pit 1 (open cut)	Bowfield	1998	2024
	South Lemington Pit 2 (open cut)	Bowfield	2015	2020
	Lemington Underground (underground)	Mt Arthur	1971	1992



LEGEND

- Approved mine footprint
- Lemington historic underground mining
- HVO gauge station
- DPI - Water gauge station
- Barrier wall
- Major drainage

HVO South - 2016 Annual Review (G1810A)

Project area

DATE 08/03/2017

FIGURE No: **2.1**

G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/02.01_G1810A_Project Area.qgs

2.2 Climate

The climate of the area is temperate and characterised by hot, wet summers and mild dry winters. Coal & Allied monitor local climatic conditions at the HVO Corp Meteorological Weather Station. Table 2.2 below summarises the monthly temperature and rainfall records.

Table 2.2 Climate averages: HVO Corp. Meteorological Data 2016

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean max temp (°C)	29	31	30	27	22	17	17	19	21	23	30	33	n/a
Mean min temp (°C)	17	18	16	14	11	8	7	6	10	11	14	17	n/a
Mean monthly rainfall since 2007(mm)	81.0	75.1	69.4	47.8	32.4	71.5	29.9	37.8	38.5	34.6	95.0	77.9	690.9*
Total monthly rainfall 2015 (mm)	202.4	10.0	45.2	6.6	20.6	81.4	38.0	22.0	87.0	39.0	60.4	80.4	693.0

Note: **Mean Annual average (2007-2016)*

The total annual rainfall for 2016 was 693 mm, which was very close to the average recorded since 2007 of 691 mm. Significant deviations from the monthly mean were recorded in January and September with twice the mean monthly rainfall. In contrast, February and April recorded seven times less than the mean rainfall.

To better understand the long term trends in monthly rainfall the Cumulative Rainfall Departure (CRD) was calculated for the period 2007 to 2016 using the data collected at the HVO Corp Weather Station. The CRD shows trends in rainfall relative to the long term average, and provides a historical record of relatively wet periods and droughts. A rising trend in slope in the CRD plot indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average.

The CRD graph for 2016 (Figure 2.2), indicates that the site experienced relatively stable rainfall during the year, with the notable exception of the significantly above average event in January. The CRD is discussed later in the report as it often is related to groundwater levels and an indicator of rainfall recharge to groundwater systems.

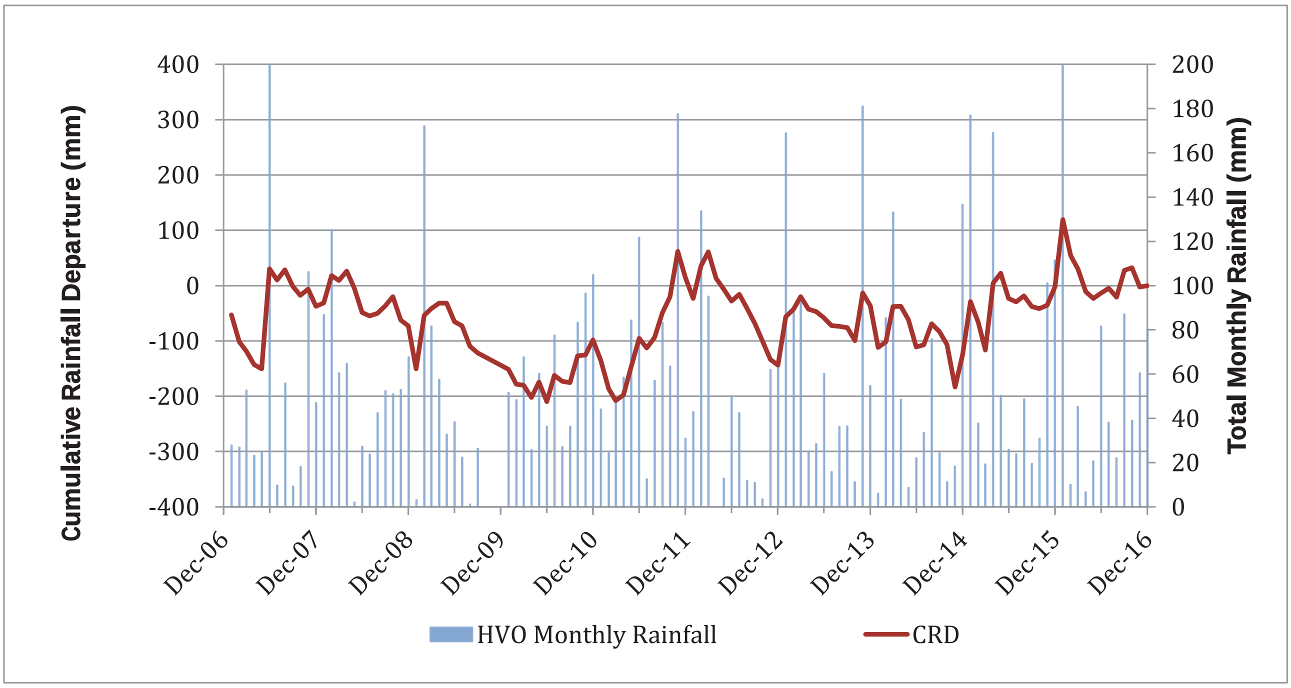


Figure 2.2 CRD and monthly rainfall records

2.3 Surface water

Coal & Allied records the water level within the Hunter River on a monthly basis at four gauging stations. Table 2.3 shows the location of the gauging stations (WLP3, WLP5, WLP10, and WLP14), with the stream level measured each month provided in Table 2.3.

Table 2.3 Hunter River water elevation monitoring (mAHD) – HVO Stations

Station ID	Easting	Northing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WLP3	312613	6401505	55.09	55.03	54.78	54.73	54.86	54.88	55.21	55.65	55.57	55.13	55.29	54.85
WLP5	311655	6400647	56.09	55.93	55.79	55.79	55.83	55.89	56.18	56.72	56.59	56.11	56.26	55.92
WLP10	310080	6401634	58.75	58.67	58.43	58.43	58.52	58.55	59.96	59.45	59.28	58.82	59.09	58.51
WLP14	308598	6402453	60.48	60.39	60.25	60.20	60.28	60.36	60.60	60.92	60.79	60.52	60.64	60.32

The data indicates stream levels were relatively stable over 2016, recording an average level of 55.1 m and 56.1 m at the downstream (WLP3) and upstream (WLP5) gauges respectively. The New South Wales Department of Primary Industries – Water (DPI Water) also record stream levels within the Hunter River and Wollombi Brook at gauging stations upstream and downstream of HVO South (Figure 2.1). Figure 2.3 shows the daily river levels recorded at Station 210083 (upstream of HVO North at Liddell), at Station 210125 (downstream of HVO North), and at Station 210004 (downstream at Wollombi Brook), along with the monthly stream levels recorded at the HVO stations. The total monthly rainfall recorded by the HVO Corp Meteorological Weather Station is also shown.

The water level and flow rate within the Hunter River is regulated by releases of water from the upstream Glenbawn Dam, which maintains a relatively constant baseflow through HVO. The water level within the river does rise in response to rainfall events, typically peaking two to three days after the event, and receding over about ten days. As shown in Figure 2.3, rises in stream levels correspond with rainfall events, with the constant baseflow maintained by releases from Glenbawn Dam during drier periods.

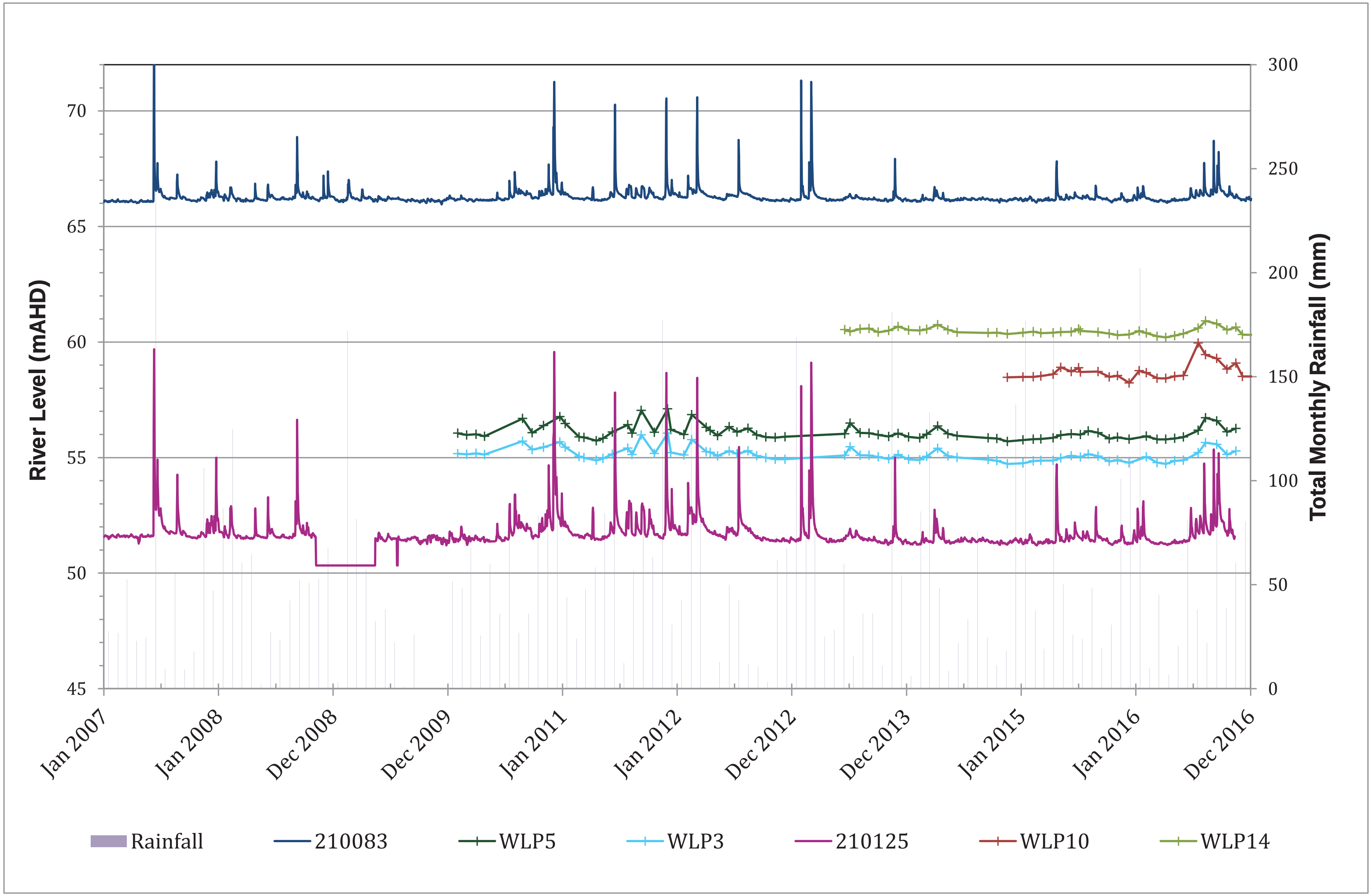


Figure 2.3 Hunter River and Wollombi Brook water levels vs total monthly rainfall

2.4 Geology

The stratigraphic sequence of the Permian coal measures is shown in Figure 2.4. The regional geology map was sourced from the 1:100,000 scale geological map, published by the Department of Mineral Resources (Glen & Beckett, 1993) and reproduced in Figure 2.5.

The Quaternary alluvium in Figure 2.5 has been digitised based on the 1:25,000 Geology Maps of Singleton (McIlveen, 1984), Muswellbrook (Summerhayes, 1983), Jerrys Plains (Sniffin & Summerhayes, 1987) and Doyles Creek (Sniffin et al, 1988). It is important to note that the mapping does not accurately define the extent of alluvium, as large-scale mapping often incorporates desktop assessment with limited ground truthing. AGE (2011) show mapping over-estimates the extent of the alluvium, which compares resistivity investigation results from Groundsearch Australia (2006) to the mapped extent from the 1:25,000 Singleton Geological Map (McIlveen, 1984). The figures also include the limit of 'highly productive alluvium' estimated by the DPI Water.

2.4.1 Stratigraphy

The stratigraphic sequence in the region comprises two distinct units, Quaternary alluvium and Permian sediments. The Quaternary alluvium consists of silt, sand and gravel in the alluvial floodplains of the Hunter River and Wollombi Brook. The alluvium unconformably overlies the Permian sediments, which comprise multiple coal seams serpated by overburden/interburden units consisting of sandstone, siltstone, tuffaceous mudstone, and conglomerate.

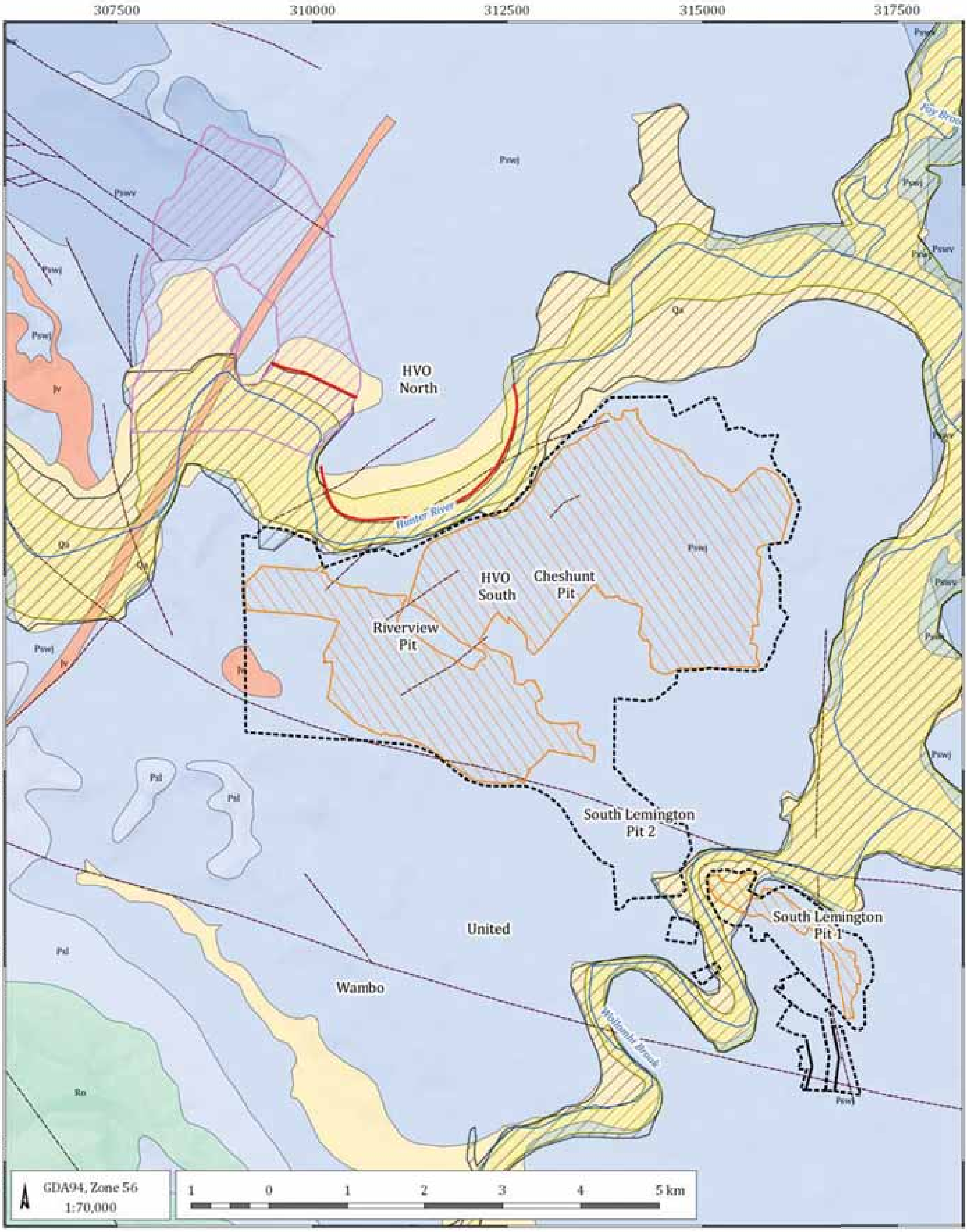
The Middle Permian rocks form a regular layered sedimentary sequence dipping in a general south-westerly direction, with the Whittingham Coal Measures containing the main economic coal seams. The Whittingham Coal Measures include the Jerrys Plains Subgroup, which is the sequence being mined at HVO South (Figure 2.5). Coal seams mined in the South Lemington Pit 1 include the Glen Munro Seam (GM), Woodlands Hill Seam (WDH), Arrowfield Seam (AFS) and Bowfield Seam (BFS). Coal seams mined in the Cheshunt Pit include the Mt Arthur Coal Seam (MTA), Piercefield Coal Seam, Vaux Coal Seam and Broonie Coal Seam. The Archerfield Sandstone and the Vane Subgroup underlie the Jerrys Plains Subgroup.

SINGLETON SUPER GROUP	WHITTINGHAM COAL MEASURES	**DENMAN FORMATION**		
		JERRYS PLAINS SUBGROUP	MOUNT LEONARD FORMATION	WHYBROW SEAM
			ALTHORPE FORMATION	
			MALABAR FORMATION	REDBANK CREEK SEAM
				WAMBO SEAM
				WHYNOT SEAM
				BLAKEFIELD SEAM
			SAXONVALE MBR	
			MOUNT OGILVIE FORMATION	GLEN MUNRO SEAM
				WOODLANDS HILL SEAM
			MILBRODALE FORMATION	
			MOUNT THORLEY FORMATION	ARROWFIELD SEAM
				BOWFIELD SEAM
				WARKWORTH SEAM
			FAIRFORD FORMATION	
			BURNAMWOOD FORMATION	MOUNT ARTHUR SEAM
				PIERCEFIELD SEAM
				VAUX SEAM
				BROONIE SEAM
				BAYSWATER SEAM inc. RAVENSWORTH
		ARCHERFIELD SANDSTONE		

Figure 2.4 Whittingham Coal Measures Stratigraphic Table

Note: South Lemington Pit – target coal seams (yellow)

Cheshunt Pit – target coal seams (green)



LEGEND

- Approved mine footprint
- Disturbance area
- Paleochannel (MER, 2005)
- Quaternary alluvium (1:25k AGE)
- Highly productive alluvium (DPI Water)
- Barrier wall
- Regional Fault
- Major drainage

Geology

- Qa - Quaternary alluvium
- Jv - Jurassic volcanics
- Rn - Narrabeen Group
- Psl - Newcastle Coal Measures
- Pswj - Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation

HVO South - 2016 Annual Review (G1810A)

Geology

AGE

DATE 06/03/2017

FIGURE No: **2.5**

2.4.2 Structural geology

The major structural feature at HVO South is the Bayswater Syncline that strikes north-south. The Bayswater Syncline is located to the east of Cheshunt Pit and west of South Lemington Pit 1. On the western limb of the Bayswater Syncline is the "*Western Graben*", which trends in a north-south direction (NTEC, 2010). Figure 2.5 shows several faults trending south-west to north-east in the Cheshunt area, and trending north to south near Lemington South Pit 1.

Resistivity studies by Groundsearch Australia (2008) have also identified two possible faults across Barry's Flat, which is located north-east of Cheshunt Pit. AGE (2010a) indicated that these two faults may have caused stratigraphic discontinuities and over-thrusting of seams.

An anticlinal structure is also present within the northern highwall of Cheshunt Pit. Figure 2.6 highlights the anticline (in red), and shows minor displacement of the coal measures along minor faults (in yellow). Along the crest of the anticline, the Mount Arthur Coal Seam appears to sub-crop beneath the alluvium (MER 2005).

Figure 2.6 Cheshunt Pit anticline

2.5 Hydrogeology

The hydrogeological setting at HVO South is comprised of shallow Quaternary alluvial aquifers, and deeper Permian coal measures. Sections 2.5.1 and 2.5.2 below detail the hydrogeological characteristics of the alluvium and Permian coal measures.

2.5.1 Alluvial aquifer

Figure 2.5 shows the mapped extent of Quaternary alluvium. AGE (2010b) assessed that the alluvium along the Wollombi Brook and Hunter River are generally 10 m to 15 m thick, with the alluvium thinning to 0 m to 5 m towards the edges of the alluvial plain. This is consistent with the Groundsearch Australia (2006) report findings of alluvium to 6.4 m depth, approximately 100 m from Wollombi Brook. The DPI Water have released maps showing the extent of 'highly productive alluvium' that is regulated under the Aquifer Interference Policy (AIP). Figure 2.5 shows the limit of hghly productive alluvium as defined by DPI Water.

Recharge to the alluvium occurs via direct rainfall infiltration as wells as via lateral seepage from the Hunter River and Wollombi Brook during periods of high flows. Resistivity studies by Groundsearch Australia (2006 and 2008) suggest a moderate to high hydraulic conductivity for the alluvium. Falling head tests on bores within the Wollombi Brook alluvium indicate a hydraulic conductivity of 0.2 m/day to 1.6 m/day (AGE, 2010b).

2.5.2 Permian coal measures

The Permian coal measures can be categorised into the following hydrogeological units:

- the majority of the Permian comprises interburden / overburden, consisting of very low to low permeability and very low yielding sandstone, siltstone and conglomerate units; and
- low to moderately permeable coal seams, each typically ranging in thickness from 2.5 m to 10 m, which are the prime water bearing strata within the Permian sequence.

The Permian coal measures occur as a regular layered south westerly dipping sedimentary sequence. In most areas around HVO South, low permeability interburden separates the alluvium and coal measures; however, MER (2005) and Groundsearch Australia (2006) reported that the coal seams may subcrop below the alluvium intermittently near Cheshunt Pit and Barry's Void.

The low to moderately permeable coal seams have recorded horizontal hydraulic conductivity (Kxy) values of between 4.0 x 10^{-3} m/day and 0.6 m/day (Rust PPK, 1997 and MER, 2005). The hydraulic conductivity of the low yielding interburden/overburden has been recorded between 1.0 x 10^{-4} m/day and 1.0 x 10^{-5} m/day (Rust PPK, 1997, MER, 2005 and AGE, 2010b).

3 Monitoring programme

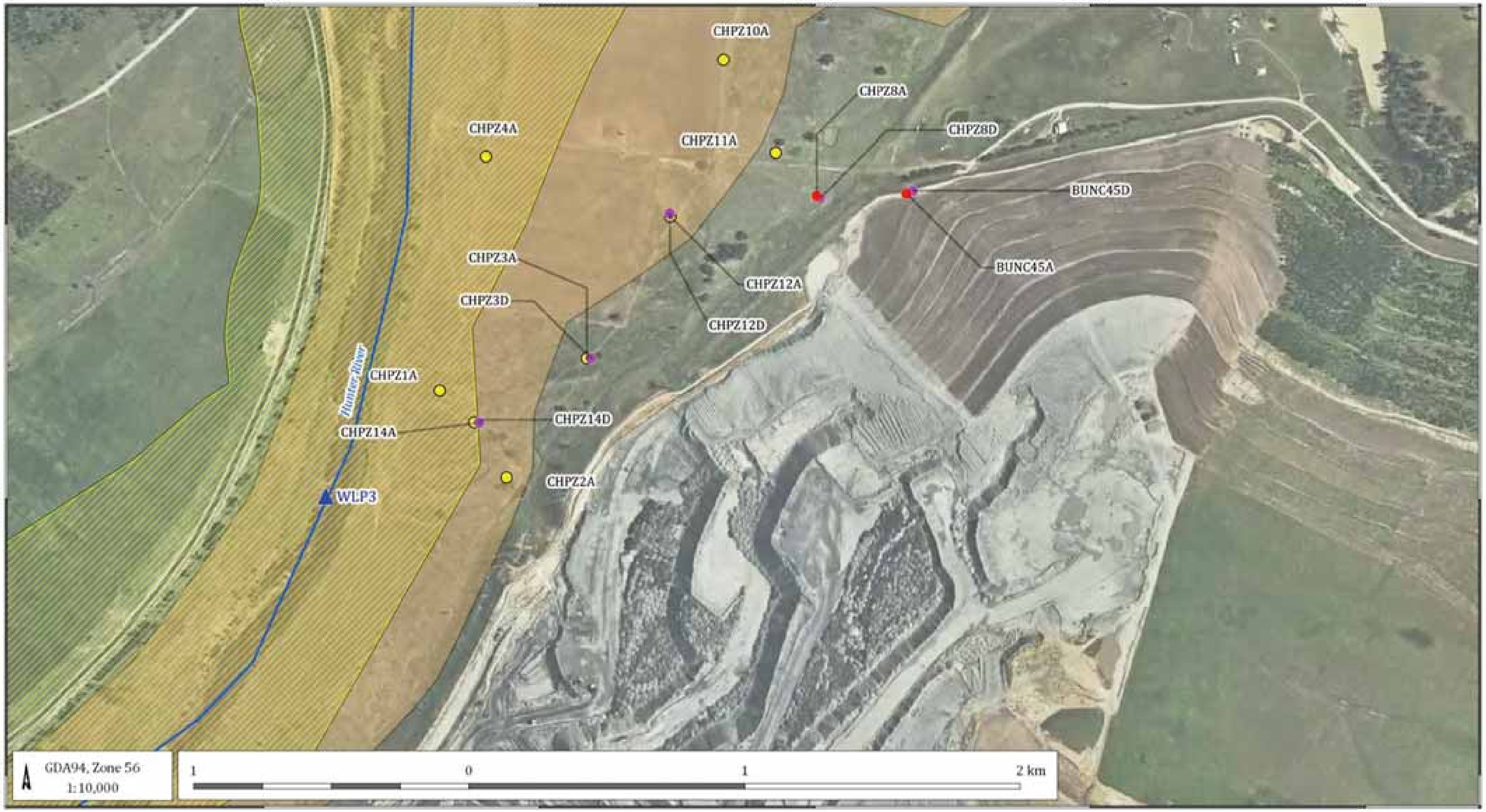
Coal & Allied have prepared a Water Management Plan (WMP) for HVO that describes groundwater monitoring programme required annually at HVO North and South. The WMP describes requirements for monitoring groundwater levels and groundwater quality and trigger levels that if exceeded require investigation. The sections below summarise the existing groundwater monitoring network and the trigger levels.

3.1 Monitoring bore network

The groundwater monitoring network at HVO South consists of 67 monitoring locations. The monitoring sites are largely standard PVC cased monitoring bores with vibrating wire piezometers (VWP) installed in some areas. There are:

- 28 monitoring bores in the Cheshunt Pit area; and
- 39 bores in the South Lemington Pit area.

Figure 3.1 to Figure 3.3 shows the location of each of the monitoring bores, with the construction details summarised within Appendix A. Table 3.1 summaries the geological formations each bore is monitoring.



LEGEND

Monitoring bore type

- Alluvium
- Mt Arthur Seam
- Regolith
- HVO gauge station

- Quaternary alluvium (1:25k AGE)
- Highly productive alluvium (DPI Water)
- Major drainage

HVO South - 2016 Annual Review (G1810A)

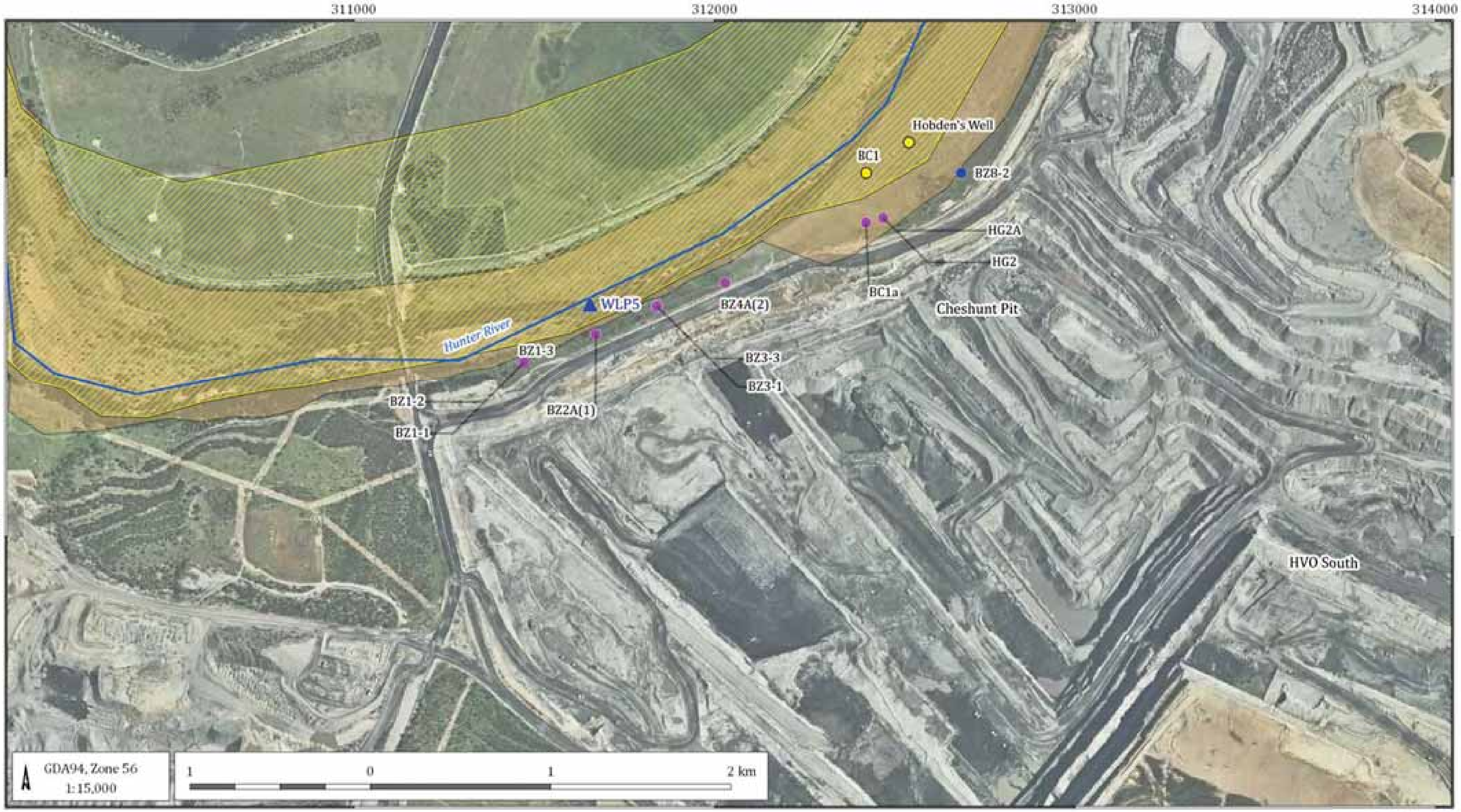
AGE

Cheshunt Pit Northern Area monitoring bore locations

DATE 06/03/2017

FIGURE No: **3.1**

G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/03.01-03.03_G1810A_monitoring bore locations.qgs



LEGEND

Monitoring bore type

- Alluvium
- Interburden
- Mt Arthur Seam

- Quaternary alluvium (1:25k AGE)
- Highly productive alluvium (DPI Water)
- Major drainage
- HVO gauge station

HVO South - 2016 Annual Review (G1810A)

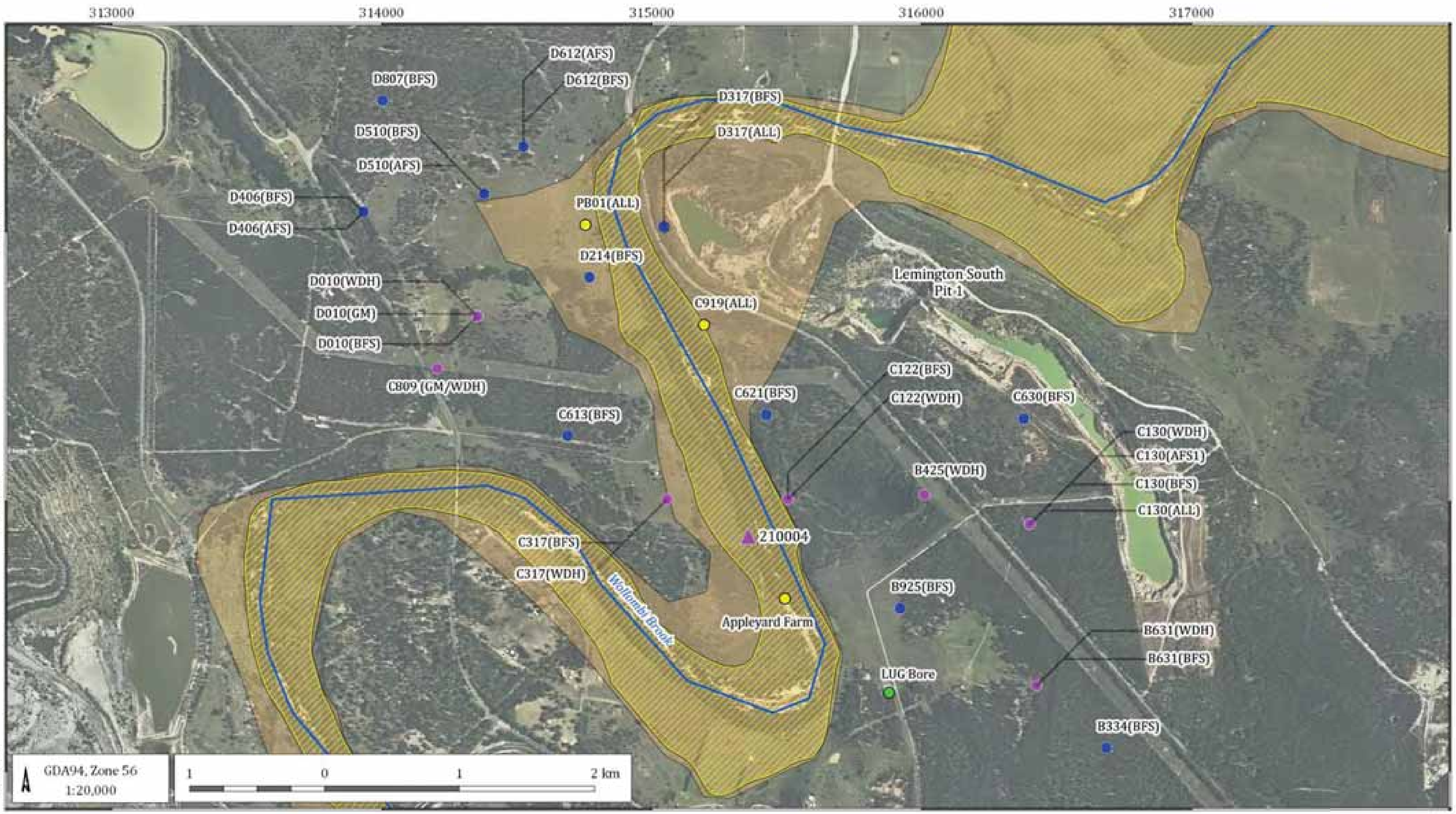
AGE

Cheshunt Pit Southern Area monitoring bore locations

DATE
06/03/2017

FIGURE No:
3.2

G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/03.01-03.03_G1810A_monitoring bore locations.qgs



LEGEND

Monitoring bore type

- Dewatering bore
- Alluvium
- Bowfield Seam
- Woodlands Hill Seam

- Quaternary alluvium (1:25k AGE)
- Highly productive alluvium (DPI Water)
- Major drainage
- DPI - Water gauge station

HVO South - 2016 Annual Review (G1810A)

Lemington monitoring bore locations

DATE
08/03/2017

FIGURE No:
3.3

G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/03.01-03.03_G1810A_monitoring bore locations.qgs

Table 3.1 Monitoring bore screened lithology

Location	Lithology	No. of bores
Cheshunt	Regolith	1
	Regolith, alluvium	1
	Alluvium	11
	Interburden	4
	Mt Arthur Seam	11
Lemington	Alluvium	4
	Interburden	1
	Glen Munro Seam	1
	Woodlands Hill Seam	7
	Arrowfield Seam	4
	Bowfield Seam	17
	Piercefield Seam	4
	Vaux Seam	1

The WMP requires the collection of water level and water quality from the monitoring network on a routine basis. Groundwater levels are measured manually and in some bores this is supplemented with data logger measurements. The water levels are measured on either a quarterly or biannual basis depending on the monitoring site. Samples are collected from the monitoring bores on a quarterly, biannual and annual basis for water quality analysis. The unstable parameter pH, along with electrical conductivity (EC) is measured in the field at the bore site. Samples are collected and sent to an analytical laboratory on a biannual or annual basis for a comprehensive analytical suite that includes:

- total dissolved solids (TDS);
- major ions - Ca, Cl, K, Mg, Na, SO_4 (or S);
- total alkalinity, bicarbonate alkalinity, carbonate alkalinity (CO_3), hydroxide alkalinity; and
- trace elements - Al, As, B, Cd, Cu, Hg, Ni, Pb, Se, Zn.

A number of samples are analysed for the above analytical suite, plus the following additional items:

- trace elements - Be, Co, F, Fe, Mn, Sb, SiO_2, Sr
- nutrients - NH_3, NO_2, NO_3, P

3.2 Trigger levels

A percentile based trigger level system has been adopted for pH and EC. In this system, the 95th percentile represents an upper trigger limit, with the 5th percentile used as the minimum pH trigger level. The WMP requires further investigation when:

- three consecutive measurements of EC or pH exceed trigger values; or
- professional judgement indicates there is potential that a single deviation or a developing trend could result in environmental harm.

4 Groundwater quality

Measurement of groundwater EC and pH was conducted at 63 bores over the 2016 monitoring period. In addition, selected bores were sampled for laboratory analysis of major ions and trace metals. The full suite of water quality results for the 2016 monitoring period is tabulated within Appendix B. Appendix B also contains graphs of water quality trends over time along with relevant trigger levels.

4.1 Field water quality measurements

The graphs and tables within Appendix B are used to identify trends in pH and EC throughout the year and to assess compliance with the requirements of the Water Management Plan. The graphs show the range in groundwater salinity as indicated by EC, which varies from fresh (Appleyard Farm) to highly saline (C130ALL), with the lowest EC measured within the alluvium in the Lemington area, and the highest within the interburden in the Lemington area. The EC recorded in all the collected samples was less than the respective trigger level, with the exception of:

- Bore C130(WDH), which exceeded the trigger levels for electrical conductivity of 19,871 µS/cm respectively for three consecutive monitoring rounds over 2015/2016. This bore shows gradually declining EC levels from initial exceedance in November 2015, but still remains above the trigger level. As this bore has exceeded trigger levels for three consecutive measurements, investigation is required as per Section 9.2 of the WMP.
- Bore PB01(ALL), which reported an EC measurement (4,510 µS/cm) above the trigger level of 3,872 µS/cm in November 2016. This is a relatively significant increase, with a similar increase observed in November 2015. Given the proximity of this bore to Wollombi Brook the observations potentially relates to low flow conditions in the Brook at the end of the dry season and/or changes in gaining/losing conditions.
- Bores B631(BFS) and D510(BFS), exceeded the trigger level of 12,460 µS/cm in May 2016. These bores also exceeded the trigger level in November 2015. Levels have since dropped below the respective trigger level in the November 2016 monitoring round.

For the 2016 monitoring period, pH results ranged from 6.3 to 8.6. Samples collected from 12 monitoring bores exceeded their respective trigger levels for pH. These bores and their respective measurements can be seen below in Table 4.1, with exceedances highlighted in bold text.

Table 4.1 2016 pH exceedances

Bore ID	Nov 2015	Feb 2016	May 2016	Sep 2016	Nov 2016
BZ2A(1)	6.3	**6.4**	**6.5**	6.7	6.6
BZ3-1	7.4	**7.8**	7.4	**7.9**	**7.8**
BZ8-2	6.7	7	**6.8**	7	6.9
HG2	6.5	6.9	**6.7**	7	6.9
Hobden's Well	7.3	7.5	7.4	**7.6**	**7.7**
B631(BFS)	**6.7**		**6.7**		**6.7**
C613(BFS)	7.1		**6.7**		7.2
C630(BFS)	7.8		**7.9**		7.8
D317(BFS)	**7.9**		**7.9**		**8.6**
D807(BFS)	7		**6.6**		7
D612(AFS)	6.8		6.9		**6.7**
C130(WDH)	6.8		6.7		**6.5**

As shown above in Table 4.1, two of the 12 bores exceeded their respective trigger levels for three consecutive measurements. As such, an investigation is required for bores B631(BFS) and D317(BFS) as per Section 9.2 of the WMP. The 10 remaining bores, while exceeding their trigger levels for pH, did so on less than three consecutive occasions, and do not need to be investigated. These measurements likely relate to natural variation, however, continued monitoring of these sites is recommended to detect any future exceedances.

4.2 Laboratory analyses

The WMP requires groundwater samples are collected from each monitoring bore annually for laboratory analysis. The review indicates some of the chemical testing committed to within the WMP appears not to have been undertaken. The annual testing data provided for 2016 excluded Cl, bicarbonate alkalinity, carbonate alkalinity, Cd, Cu, Hg, Ni, Pb, Be, Co, F, Sb, $Si0_2$, NH_3, NO_2, NO_3.

5 Groundwater levels

Manual recording of groundwater levels within monitoring bores at HVO South has been undertaken since 2007. The manual water level measurements are also supplemented with water levels recorded automatically by data loggers installed in 16 locations since 2009. This report specifically examines trends recorded over the 2016 calendar year; however, data since 2014 is presented to ensure longer term trends are considered. Appendix C contains groundwater hydrographs for each of the bores, with groundwater level contours provided within Figure 5.1 to Figure 5.3.

Groundwater levels were measured at 63 bores across the 2016 monitoring period, with four of these being dry. These bores were D317(ALL), BC1, BZ1-2, and C122(BFS).

The groundwater levels were compared against the CRD and Hunter River levels recorded at the DPI Water gauging station 210125, as well as Wollombi Brook water levels recorded at gauging station 210004. The CRD and river level measurements allow the relationship between groundwater levels, rainfall recharge and river connectivity to be better understood. This is important as these natural influences on groundwater levels need to be separated from the potential influence of mining activities. Sections 5.1 - 5.3 below discuss further the groundwater levels observed with the alluvial and the Permian groundwater systems respectively.

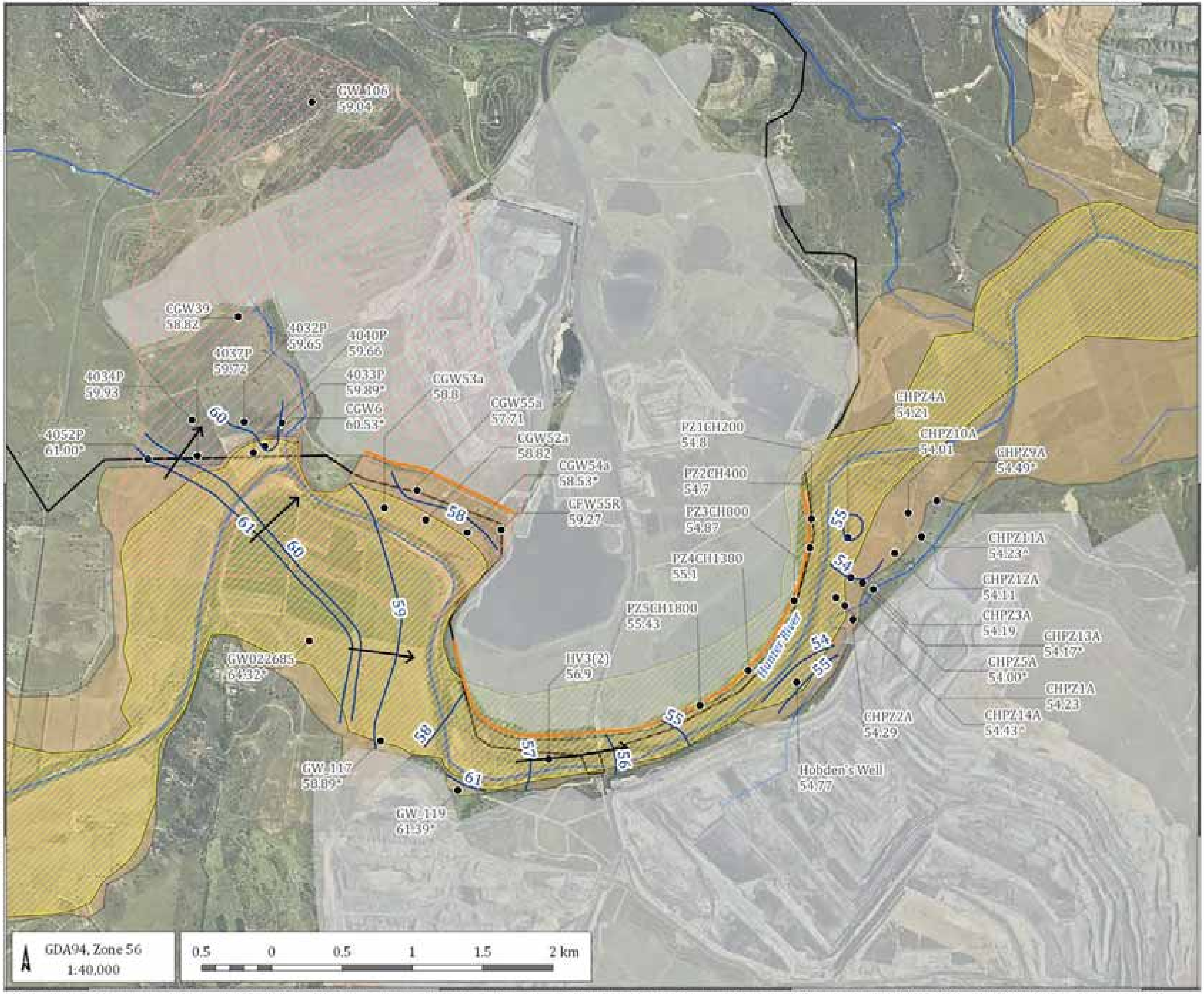
5.1 Cheshunt Pit – Northern Area

5.1.1 Alluvium

Figure 5.1 shows that groundwater within the Quaternary alluvium generally flows in an easterly 'downstream' direction, following the grade of the Hunter River.

As discussed, Appendix C contains hydrographs showing the long-term trends in groundwater levels for bores installed within alluvium. These hydrographs are compared with water level records collected from the closest operating Hunter River gauging station. As seen in Appendix C, Figure C.1, alluvial groundwater levels were relatively stable over the 2016 monitoring period, with slight increases seen in July. This rise in water levels corresponds with increases in river water levels at gauging stations WLP3 and 210125 indicating connectivity between the alluvial aquifer and the Hunter River.

The groundwater levels were below river levels (recorded at WLP3) during 2016 which sugests the potential for recharge from the surface water into the underlying alluvium, which was also noted during the previous reporting year. Groundwater levels within the alluvium appear largely influenced by climate and do not indicate any discerable influence from mining at HVO South during the 2016 reporting period.



^ Water level February 2016
* Water level September 2015

HVO South - 2016 Annual Review (G1810A)

Alluvium groundwater level contours - May - June 2016

DATE
06/03/2017

FIGURE No:
5.1

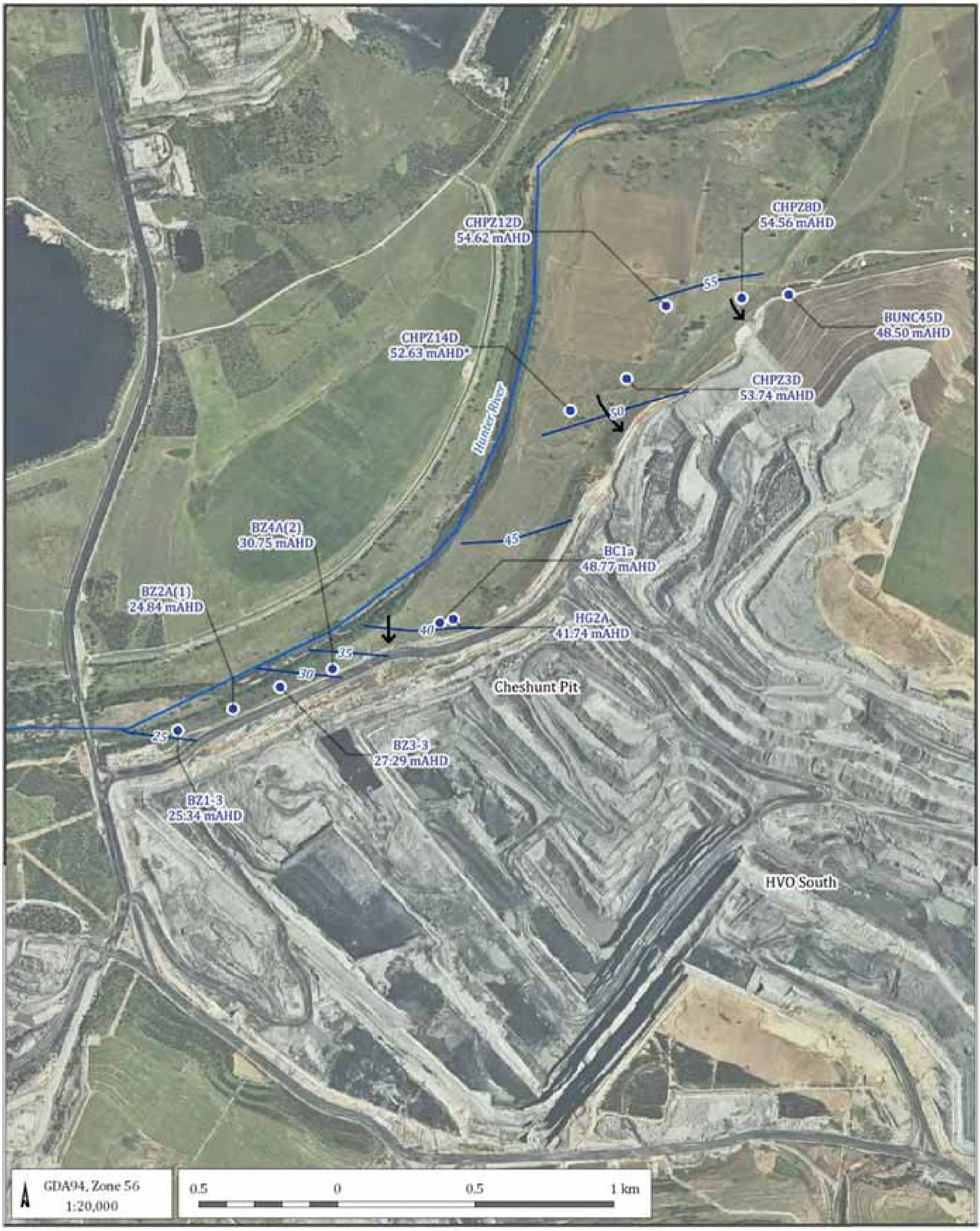
G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/05.01_G1810A_Alluvium groundwater level contours - May - June 2016.qgs

5.1.2 Mount Arthur Seam (MTA)

Figure 5.2 shows that groundwater within the Mount Arthur Seam generally flows in a southerly direction, toward the Cheshunt Pit. The hydrograph presented in Appendix C, Figure C.2, displays relatively stable water levels, with slight fluctuations corresponding with increased surface water levels recorded at gauging stations WLP3 and 210125. This suggests a hydraulic connection between the coal seam and the river, likely where the Mt Arthur Seam subcrops beneath both the River and the alluvium to the north–west of Barry's Pit. Bore BUNC45D, located adjacent to the historic Barry's Pit Void (used for mine water storage until 2014), displayed declining water levels over the 2014 to 2015 monitoring periods. Water levels have since stabilised remaining ~48.5 mAHD since July 2015.

5.1.3 Regolith

As presented in Appendix C, Figure C.3, groundwater levels at bore CHPZ8A within the regolith in the Cheshunt Pit area remain relatively stable for the 2016 monitoring period, with fluctuaions corresponding with changes in the CRD and surface water levels recorded at gaugings stations WLP3 and 210125. Similar to the trend mentioned above, BUNC45A recorded a decline in water levels over 2014/2015, but has since stabilised, with no further declining trend in 2016. Due to proximity to Barry's Pit these fluctuations are most likely attributed to adjacent mining activities.



LEGEND

- Groundwater monitoring bore, Observed water level (mAHD)
- Groundwater flow direction
- Groundwater contour (mAHD)
- Major drainage

HVO South - 2016 Annual Review (G1810A)

Mt Arthur Seam groundwater level contours – Cheshunt area – November 2016

AGE

DATE 06/03/2017

FIGURE No: 5.2

* Water level February 2016

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.; G:/Projects/G1810A.RTCA_HVO South Annual Review 2016/3_GIS/Workspaces/001_Deliverable1/05.02-05.03_G1810A_HVO South_GW_contours.qgs

5.2 Cheshunt Pit – Southern Area

5.2.1 Alluvium and interburden

Three alluvial aquifer monitoring bores are present in the Cheshunt Pit – Southern Area. These are BC1, BZ1-2 and Hobden's Well with depths of 8.5 m, 10 m and 13.9 m respectively. Of the three bores, BC1 and BZ1-2 were dry throughout 2016. As seen in Appendix C, Figure C.4, bores screened within the interburden (BZ1-1, BZ3-1, BZ8-2, and HG2) display similar groundwater levels and fluctuations to those in the alluvium (Hobden's Well). Both alluvial and interburden bores recorded water level trends related to changes in surface water levels recorded at gauging stations WLP3 and 21025 and the CRD, again suggesting connectivity between the Hunter River and the alluvium.

5.2.2 Mount Arthur Seam (MTA)

As discussed in Section 5.1.2, groundwater within the Mount Arthur Seam generally flows in a southerly direction, toward the Cheshunt Pit. The hydrographs presented in Appendix C, Figure C.5, display no obvious correlation between the CRD/surface water levels and groundwater levels within the Mount Arthur Seam. Bores in close proximity to Cheshunt Pit (BZ1-3, BZ2A(1), & BZ3-3) display an initial decrease in water levels from 2014 to 2015 followed by groundwater level staballisation. Bores BC1a & HG2A, located further from active mining, display higher, stable groundwater levels, with no impact from mining evident.

5.3 South Lemington Pit 1

5.3.1 Alluvium

Figure 5.3 shows that groundwater within the Quaternary alluvium in the South Lemington area flows predominantly downstream along the Wollombi Brook. The frequency of monitoring in bores C130(ALL), C919(ALL), D317(ALL) and PB01(ALL) was increased from 6-monthly to monthly in 2014. A review of the monitoring program was undertaken in late 2013, following the receipt of a licence to abstract water from the disused Lemington Underground mine workings via the LUG Bore. A bore at Appleyard Farm, has been monitored monthly since 2012.

Appendix C, Figure C.6, presents groundwater levels for the South Lemington alluvial bores from 2014 to 2016. Overall, groundwater levels within the alluvium at South Lemington are relatively stable over the 2016 monitoring period, with fluctuations observed corresponding to changes in surface water levels recorded at gauging station 210004 and the CRD, indicating a hydraulic connection between the Wollombi Brook and alluvium. All alluvial bores display similar responses to changes in surface water levels. Bore D317(ALL) remained dry over the 2016 monitoring period. No impact from abstraction from the LUG bore is evident within the alluvium.

5.3.2 Woodlands Hill Seam (WDH) and Glen Munro Seam (GM)

As seen in Appendix C, Figure C.7, groundwater levels measured within the Woodlands Hill and Glen Munro seams recorded little change over the 2016 monitoring period, with levels stable since 2014. Slight variations observed appear to correlate to fluctuations in the CRD.

5.3.3 Arrowfield Seam (AFS)

Groundwater levels in four bores constructed to the Arrowfield Seam were recorded over the 2016 monitoring period. Appendix C, Figure C.8, show that groundwater fluctuates in response to climate, however a slight rising trends can be observed since 2014.

5.3.4 Bowfield Seam (BFS)

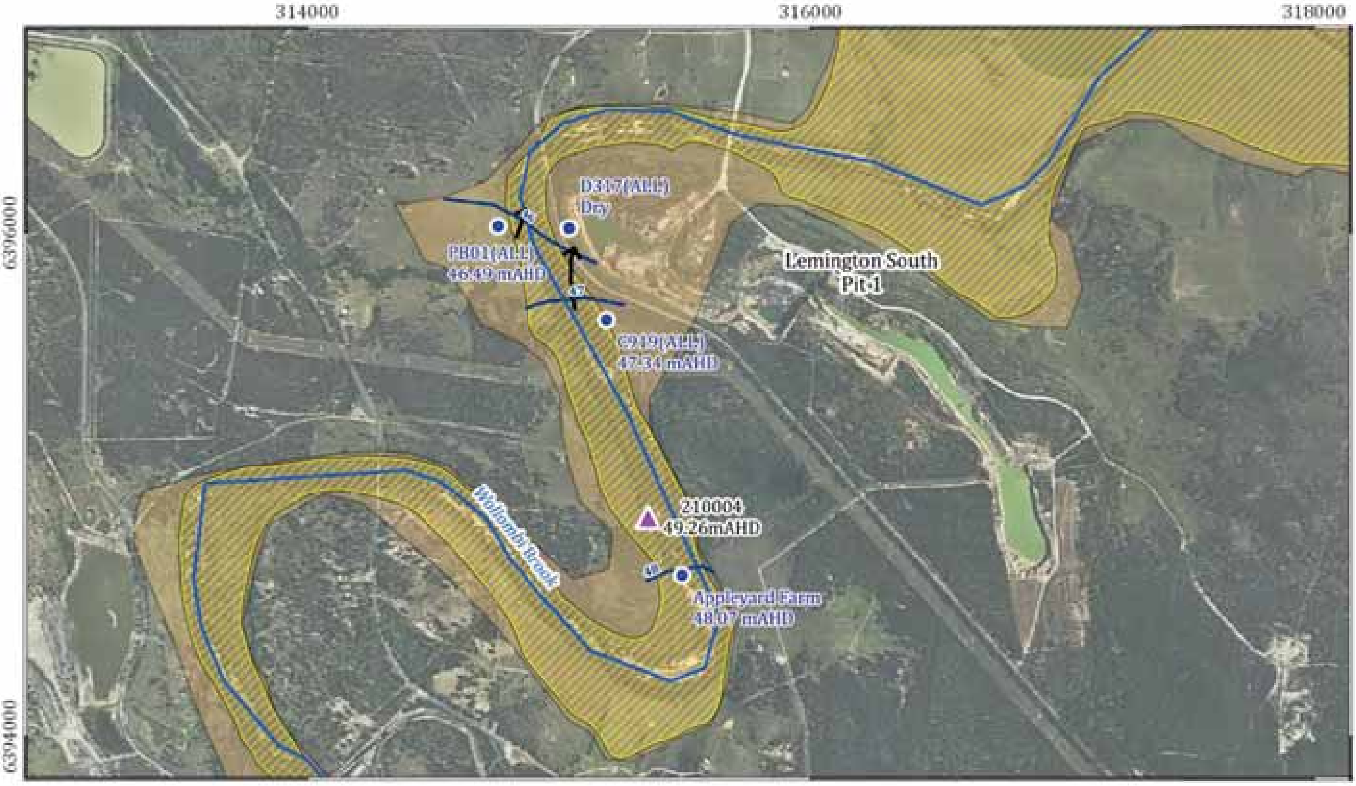
Groundwater levels were measured at 16 bores screened in the Bowfield Seam over the 2016 monitoring period. Eight of these bores are located north of Wollombi Brook, and eight are located to the south. Hydrographs for 15 of these bores are presented in Appendix C, Figure C.9 and Figure C.10. Bore C122(BFS) is not presented as it has remained dry over the graphed period.

Figure 5.3 shows that groundwater within the Bowfield Seam, in the vicinity of South Lemington Pit 1, generally flows in a south-westerly direction away from the pit. West of the Wollombi Brook, groundwater flows in a north-westerly direction.

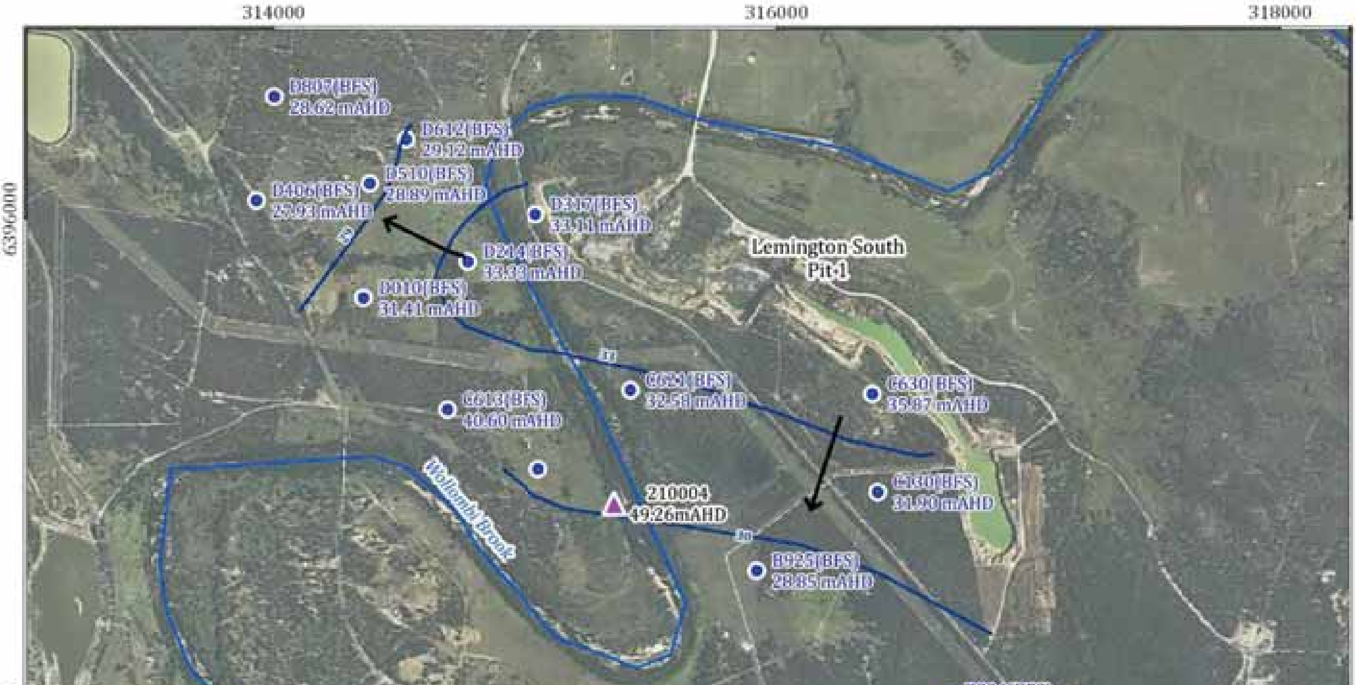
South of the pit void, groundwater levels in the Bowfield Seam record similar fluctuations for all monitoring bores, which correponds to trends observed in the CRD. The groundwater level variation recorded in bore B631(BFS) is slightly less than the other bores.

North of the pit void, groundwater levels remained stable to slightly rising over the 2016 monitoring period. This increase, similar to that observed in other seams in the area, is likely due to trends observed in the CRD, and potentially changes in water storage within the pit void.

Alluvium groundwater contours



Bowfield Seam groundwater contours



LEGEND

- Quaternary alluvium (1:25k AGE)
- Highly productive alluvium (DPI Water)
- Surface water monitoring sites
- Groundwater monitoring bore, Observed water level (mAHD)
- Groundwater flow direction
- Groundwater contour (mAHD)
- Major drainage

HVO South - 2016 Annual Review (G1810A)

Lemington South groundwater contours - November 2016

DATE 10/03/2017

FIGURE No: 5.3

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6 Water take and licensing

6.1 Legislation

Department of Primary Industries – Water (DPI Water) manage groundwater in the region in accordance with the *Water Management Act 2000*, under which Water Sharing Plans (WSP) have been developed to share water resources equitably among users. At HVO South the following plans apply for:

- Alluvial groundwater - Hunter Unregulated and Alluvial Water Sources WSP;
- Hunter River surface water - Hunter River Regulated Water Source WSP; and
- Bedrock groundwater including coal measures - North Coast Fractured and Porous Rock WSP.

The New South Wales Aquifer Interference Policy (AIP) requires mines account for all 'water take' due to mining, both directly and indirectly. The 'water take' must be accounted for with water access licenses issued by the DPI Water under the relevant WSP.

6.2 Methods to estimate 'water take'

Mining activities create a zone of low or zero water pressure within the mining area, which induces groundwater to flow directly into the active mining area. At many coal mines, the volume of groundwater ingress into the active mining areas cannot be directly measured because it is volumetrically relatively small, and not collected at a single point. Groundwater entering the mining area is also subject to range of processes including evaporation from the mine face, mixing with surface runoff and adhering to mined materials that prevent direct measurement of groundwater inflow volumes.

Mining typically also reduces groundwater pressures in strata directly surrounding the mining area. Where there is a change in water level and pressure due to the mining this is typically referred to as the 'zone of influence' or the 'cone of depression'. The pressure changes within the zone of influence can change the volumes of groundwater moving into aquifers adjacent to mining areas. This results in an 'indirect take' of groundwater, sometimes referred to as a 'passive take'. The indirect take does not necessarily flow into the active mining area, but represents a reduced flow to aquifers not being directly excavated by mining.

The currently active HVO South mining areas do not record continuous measurable groundwater inflow to the mining areas, as evaporation from the mine face, mixing with surface runoff and adhering to mined materials prevents direct measurement. In the absence of direct measurements, of 'water take', models are required to estimate the volume of water taken during mining operations. There are three types of models commonly used for this purpose:

1. numerical groundwater flow models;
2. analytical groundwater flow models; and
3. water budget models.

Over time Coal & Allied have utilised all of the above methods to estimate volumes of direct and indirect water take from the groundwater systems at HVO North. Previous annual reviews conducted for HVO South have utilised an analytical method to estimate volumes of groundwater draining indirectly from the alluvial strata into the mining area. It is understood that Coal & Allied also have developed mine water balance models for HVO South for water management purposes that have potential to provide back-calculated estimates of groundwater ingress to mining areas. The most recent public domain numerical groundwater flow model which provides estimates of groundwater ingress into the HVO South mining areas was released in 2017 and is described by AGE (2017). This model provides estimates of 'water take' for a proposal to deepen the mining areas to extract the Bayswater coal seam.

It is important to note all of these methods have limitations, and ultimately provide an **estimate only** of an immeasurable quantity of water. The estimates cannot be directly validated, as there is no measured data to compare estimates from models with, however the estimates from the various modelling methodologies can be compared with each other. The sections below present estimates of 'water take' from numerical and analytical methods, and compare the results with WALs held.

6.3 Numerical modelling estimates of 'water take'

Table 6.1 below summaries the water access licenses (WAL) held by Coal & Allied to account for groundwater directly intercepted by mining activities, and the estimates from the most recent numerical modelling undertaken for HVO South by AGE (2017).

Table 6.1 Water licenses and numerical modelling estimates of 'water take' at HVO South

Water Sharing Plan	Entitlement (ML) and WAL	Estimated 2016 direct water take (ML)	Estimated maximum direct take (ML)[1]
North Coast Fractured and Porous Rock Groundwater [2]	3,040 (WAL40462, WAL40466, WAL40463)	917	1,591
Hunter Regulated River	3,165 (WAL962)	0	584
Hunter Unregulated and Alluvial Water Sources (Hunter river alluvium)	383 (WAL18127)	167	358
Hunter Unregulated and Alluvial Water Sources (Wollombi Brook alluvium & surface water)	144 (WAL23889)	0	131

1. *From estimates presented in AGE (2017) HVO South Modification 5 Groundwater Study – Prepared for EMM Consulting Pty Ltd, January 2017*
2. *This Water Sharing Plan commenced in July 2016 midway through the annual review period. The area was formerly regulated under the Water Act 1912, and as part of the change in legislation water licenses are being converted to new formats. It is understood the conversion process is still underway at the time of writing. These WALs are to account for 'water take' from both HVO North and HVO South mines*

The most recent groundwater modelling conducted by AGE (2017) for HVO South focussed on assessing the impact and 'water take' of increasing the depth of mining to include removal of the Bayswater coal seam. The modelling provided future predictions of 'water take' only, and therefore did not provide an estimate of take over the 2016 annual review period. However the 'model year 1' approximates existing conditions and can be used to provide an estimate of water take for 2016, which is presented in Table 6.1 The table indicates Coal & Allied hold sufficient WALs to account for the current and estimated peak take of groundwater and surface water induced by mining activities at HVO South.

6.4 Analytical estimates of 'water take'

As discussed previously analytical methods can also be used to estimate the volume of groundwater ingress to the mining area and the indirect take from the Hunter River alluvium. Previous annual reviews for both HVO North and HVO South have utilised an analytical method to estimate the transfer of alluvial and Permian groundwater into the mining areas. The analytical methods require a range of assumptions that make the estimates less rigorous than those obtained from numerical modelling. Therefore, use for estimates from numerical modelling is recommended.

6.5 Limitations

As discussed above where groundwater systems have a relatively poor ability to transmit groundwater, as occurs at coal mines 'water take' cannot be directly measured, but only estimated indirectly using a variety of modelling methods.

The most recent numerical modelling conducted for HVO South, whilst it does not provide estimates of 'water take' during 2016, does indicate the water take is likely to remain less than the WALs limits used to account for the impact of mining.

The analytical methods that have been used in previous Annual Reviews are a 2D simplification of a more complex hydrogeological system, and therefore contain some inherent uncertainty. Given the availability of estimates from numerical modelling, the use of the analytical methods is no longer considered warranted.

As noted above these limitations mean the 'water take' for 2016 can only ever be an estimate, and different methods will provide differing estimates due to the underlying assumptions. In despite of this the available information indicates 'water take' due to mining is less than the WAL entitlements.

7 Lemington Underground (LUG) bore compliance

Lemington Underground (LUG) bore licence (20BL173392) was granted on 23rd September 2013 and allows the abstraction of up to 1,800 ML/annum between 1 July and 30 June. The LUG bore is installed within the abandoned LUG mine void to supply water to both HVO and Mount Thorley Warkworth (Rio Tinto, 2014). The following sections address the key criteria and licence conditions for LUG Bore licence 20BL173392 (replaced by WAL39798, however existing conditions of 20BL173392 still apply).

7.1 Abstraction data

Table 7.1 summarised the volume of groundwater abstracted each month for the licence reporting period July 2015 to June 2016. Table 7.1 shows a total of 169 ML was pumped from the bore over the water year, which is about 9% of the annual allocation.

Table 7.1 Summary Groundwater Abstraction Data

Month / Year	Groundwater Extracted (ML)
July 2015	0
August 2015	0
September 2015	0
October 2015	0
November 2015	0
December 2015	0
January 2016	0
February 2016	0
March 2016	0
April 2016	11.61
May 2016	135.02
June 2016	22.30
Total	168.93

7.2 LUG Bore monitoring data

Table D 1 (Appendix D) summarises details of monitoring bores that are present in proximity to the LUG bore. The Lemington Underground Mine targeted the Mt Arthur coal seam, with the surrounding monitoring bores monitoring groundwater levels within the overlying seams and the Wollombi Brook alluvium. Groundwater levels measured within the monitoring network were used to create the groundwater hydrographs presented in Appendix C. The sections below discuss the measured groundwater levels and the potential for the abstraction from the LUG bore to have induced drawdown in the alluvium and coal seam aquifers.

7.2.1 Alluvial Groundwater level near LUG Bore

Over the 2015 / 2016 reporting period, groundwater levels recorded within alluvial bores PB01(ALL), C919(ALL) and Appleyard Farm continue to be correlated with fluctuations in the CRD and surface water levels within Wollombi Brook. Extraction from the LUG bore showed no visible effect on groundwater levels over the 2015 / 2016 water year.

7.2.2 Coal Seam groundwater levels near LUG Bore

The abstraction from the LUG bore did not result in any readily identifiable water level changes within the overlying Permian coal seams over the 2015 / 2016 water year. Similar to the alluvial water levels the groundwater levels within the Permian units were relatively stable, with fluctuations corresponding to trends observed in the CRD and potentially changes in water levels within South Lemington Pit 1. Review of water level records for each coal seam indicates:

- Woodlands Hill Seam and Glen Munro Seam - relatively stable levels that fluctuate in relation to climate.
- Arrowfield Seam – a slight rising trend is evident which is overprinted with climate fluctuations.
- Bowfield – water level fluctuations correlated with climate, and potential water level changes in South Lemington Pit 1.

7.3 Summary and recommendations

Based on available data, LUG Bore (20BL173392 / WAL39798) complies with current licencing conditions, with no observable effects of extraction on either alluvial or Permian aquifers. The limited abstraction from the bore and the lack of discernible change in overlying water levels indicates there would be no flow on effects for water users, i.e private bores or ecosystems. Ongoing monitoring of the LUG Bore monitoring network is recommended.

8 Conclusions

The groundwater monitoring data for the 2016 calander year was reviewed and it was concluded:

- Groundwater levels over the site remained relatively stable over the 2016 monitoring period, with increases and fluctuations within the Permian coal seams attributed to climatic influences. Locally around the mining areas the following trends were evident:
  - In the Cheshunt Pit area, groundwater within the Hunter River alluvium continues to flow dowstream along the river. In the South Lemington area, alluvial groundawter also indicates flow is predominantly downstream along the Wollombi Brook.
  - Groundwater levels around the northern portion of the Cheshunt area and South Lemington Pit 1 respond to peak flow events at Hunter River and Wollombi Brook gauging stations. The groundwater elevation within the alluvium is lower than the Hunter River indicating that the river is a source of recharge.
  - Groundwater within Mount Arthur Seam generally flows toward the south and the actively mined Cheshunt Pit, which is consistent with the 2015 reporting period.
  - Groundwater within the Bowfield Seam continues to flow south away from South Lemington Pit 1, and in a north-westerly direction west of the Wollombi Brook.
- Three consecutive measurements of either pH and / or EC over the respective trigger levels occurred at bores C130(WDH), B631(BFS), and D317(BFS). Section 9.2 of the WMP requires a site specific investigation into the above exceedances; refer to Annual Environmental Review for findings. These bores are in proximity to the South Lemington Pit 1 where water is stored for reuse in mining – the potential for connectivity with this pit should be considered as part of the investigation.
- Numberical modelling indicates water take is likely to remain less than the WALs limits used to account for the impact of mining.
- LUG Bore (20BL173392, WAL39798) complies with current licencing conditions, with no observable effects of extraction on either the alluvial or Permian groundwater systems.

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Appendix A Monitoring bore construction details

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
CHPZ10A	MB	EX	313334	6402297	63.4	0.8	12.6	9.5	12.6	-	-	50	Alluvium	Cheshunt
CHPZ11A	MB	EX	313429	6402129	61.9	1.0	10.6	7.2	10.6	-	-	50	Alluvium	Cheshunt
CHPZ12A	MB	EX	313238	6402013	63.5	0.3	11.5	9.5	11.5	-	-	50	Alluvium	Cheshunt
CHPZ14A	MB	EX	312883	6401639	66.0	0.4	16.0	12.8	16.0	-	-	50	Alluvium	Cheshunt
CHPZ1A	MB	EX	312820	6401697	65.9	1.0	18.7	15.0	18.7	-	-	50	Alluvium	Cheshunt
CHPZ2A	MB	EX	312941	6401539	65.8	0.6	16.9	13.7	16.9	-	-	50	Alluvium	Cheshunt
CHPZ3A	MB	EX	313086	6401756	63.9	0.7	14.5	14.5	11.5	-	-	50	Alluvium	Cheshunt
CHPZ4A	MB	EX	312904	6402123	66.3	0.8	14.2	10.9	14.2	-	-	50	Alluvium	Cheshunt
BUNC45D	MB	EX	313677	6402060	73.8	0.4	30.7	25.9	28.9	-	-	50	Mt Arthur Seam	Cheshunt
CHPZ12D	MB	EX	313236	6402019	63.6	0.3	14.3	12.0	15.0	-	-	50	Mt Arthur Seam	Cheshunt
CHPZ14D	MB	EX	312891	6401639	65.9	0.3	18.8	28.8	25.6	-	-	50	Mt Arthur Seam	Cheshunt
CHPZ3D	MB	EX	313094	6401756	63.7	0.6	16.0	20.5	23.6	-	-	50	Mt Arthur Seam	Cheshunt
CHPZ8D	MB	EX	313508	6402047	61.2	1.1	9.5	6.0	9.5	-	-	50	Mt Arthur Seam	Cheshunt
BUNC45A	MB	EX	313667	6402055	73.3	0.3	21.2	17.3	20.3	-	-	50	Regolith	Cheshunt
CHPZ8A	MB	EX	313503	6402051	60.9	0.8	6.3	4.0	6.0	-	-	50	Regolith, alluvium	Cheshunt
BC1	MB	AU	312421	6401010	66.4	0.3	8.5	-	-	-	-	-	Alluvium	Cheshunt
BZ1-2	MB	AU	311472	6400483	71.8	0.4	-	7.0	10.0	-	-	-	Alluvium	Cheshunt
Hobden's Well	MB	EX	312540	6401093	71.0	0.7	13.9	-	-	-	-	-	Alluvium	Cheshunt
BZ1-1	MB	EX	311472	6400483	71.8	0.4	-	21.0	24.0	-	-	-	Interburden	Cheshunt
BZ3-1	MB	EX	311840	6400640	70.3	0.3	26.2	-	-	-	-	-	Interburden	Cheshunt

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
BZ8-2	MB	EX	312685	6401010	67.8	-	-	-	-	-	-	-	Interburden	Cheshunt
HG2	MB	EX	312469	6400886	67.5	0.6	15.5	-	-	-	-	-	Interburden	Cheshunt
BC1a	MB	EX	312421	6400872	66.4	0.3	21.1	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ1-3	MB	EX	311472	6400483	71.8	0.4	35.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ2A(1)	MB	EX	311671	6400561	71.7	0.4	39.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ3-3	MB	EX	311840	6400640	70.3	0.4	38.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ4A(2)	MB	EX	312029	6400705	74.4	0.6	41.4	-	-	-	-	-	Mt Arthur Seam	Cheshunt
HG2A	MB	EX	312469	6400886	67.5	0.6	27.8	-	-	-	-	-	Mt Arthur Seam	Cheshunt
Appleyard Farm	MB	EX	315491	6394639	43.4	0.8	10.0	7.0	10.0	-	-	-	Alluvium	Lemington
C919(ALL)	MB	EX	315192	6395655	58.0	0.3	11.5	-	-	-	-	-	Alluvium	Lemington
D317(ALL)	MB	EX	315044	6396018	59.5	0.3	14.7	9.2	12.2	-	-	-	Alluvium	Lemington
PB01(ALL)	MB	EX	314754	6396026	55.0	-	-	-	-	-	-	-	Alluvium	Lemington
C130(AFS1)	MB	EX	316400	6394916	63.0	0.3	42.2	-	-	-	-	-	Arrowfield Seam	Lemington
D406(AFS)	MB	EX	313931	6396074	57.0	0.3	-	-	-	-	-	-	Arrowfield Seam	Lemington
D510(AFS)	MB	EX	314380	6396141	54.8	0.3	30.5	25.5	30.5	-	-	-	Arrowfield Seam	Lemington
D612(AFS)	MB	EX	314524	6396314	62.0	0.4	0.0	-	-	-	-	-	Arrowfield Seam	Lemington
B334(BFS)	MB	EX	316684	6394088	73.0	0.3	51.8	58.5	-	-	-	-	Bowfield Seam	Lemington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
B631(BFS)	MB	EX	316425	6394319	72.0	0.3	36.1	78.0	-	-	-	-	Bowfield Seam	Lemington
B925(BFS)	MB	EX	315921	6394604	65.0	0.4	41.2	81.0	-	-	-	-	Bowfield Seam	Lemington
C122(BFS)	MB	EX	315501	6395007	58.0	-	-	-	-	-	-	-	Bowfield Seam	Lemington
C130(BFS)	MB	EX	316400	6394916	63.0	0.0	64.5	55.0	61.0	-	-	-	Bowfield Seam	Lemington
C317(BFS)	MB	EX	315054	6395007	60.0	0.4	76.2	-	-	-	-	-	Bowfield Seam	Lemington
C613(BFS)	MB	EX	314688	6395243	63.0	0.3	85.5	-	-	-	-	-	Bowfield Seam	Lemington
C621(BFS)	MB	EX	315421	6395321	58.0	0.3	57.5	-	-	-	-	-	Bowfield Seam	Lemington
C630(BFS)	MB	EX	316378	6395306	69.0	0.3	49.1	-	-	-	-	-	Bowfield Seam	Lemington
D010(BFS)	MB	EX	314355	6395687	56.0	0.4	68.1	-	-	-	-	-	Bowfield Seam	Lemington
D214(BFS)	MB	EX	314768	6395831	56.5	0.3	53.5	43.0	52.5	-	-	-	Bowfield Seam	Lemington
D317(BFS)	MB	EX	315043	6396019	59.5	0.3	44.0	39.0	44.2	-	-	-	Bowfield Seam	Lemington
D406(BFS)	MB	EX	313931	6396074	57.0	0.3	61.3	-	-	-	-	-	Bowfield Seam	Lemington
D510(BFS)	MB	EX	314380	6396141	54.8	0.3	38.0	34.0	38.0	-	-	-	Bowfield Seam	Lemington
D612(BFS)	MB	EX	314524	6396314	62.0	0.3	35.1	-	-	-	-	-	Bowfield Seam	Lemington
D807(BFS)	MB	EX	314002	6396484	59.7	0.4	41.0	36.0	41.0	-	-	-	Bowfield Seam	Lemington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
D010(GM)	MB	EX	314355	6395687	56.0	-	-	-	-	-	-	-	Glen Munro Seam	Lemington
C130(ALL)	MB	EX	316400	6394916	63.0	0.3	17.0	-	-	-	-	-	Interburden?	Lemington
C1(WJ039)	MB	EX	317142	6400707	71.2	-	-	-	-	-	-	-	Piercefield Seam	Lemington
GW9701	MB	EX	315901	6401798	93.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
GW9702	MB	EX	316436	6401479	98.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
GW9710	MB	EX	316700	6400486	82.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
F1.5(WF533)	MB	EX	316607	6398247	54.9	-	-	-	-	-	-	-	Vaux Seam	Lemington
B425(WDH)	MB	EX	316010	6395024	58.0	-	55.0	-	-	-	-	-	Woodlands Hill Seam	Lemington
B631(WDH)	MB	EX	316424	6394319	72.0	-	30.7	-	-	-	-	-	Woodlands Hill Seam	Lemington
C122(WDH)	MB	EX	315501	6395007	58.0	0.3	22.7	-	-	-	-	-	Woodlands Hill Seam	Lemington
C130(WDH)	MB	EX	316400	6394916	63.0	0.4	21.6	-	-	-	-	-	Woodlands Hill Seam	Lemington
C317(WDH)	MB	EX	315054	6395007	60.0	0.2	33.9	-	-	-	-	-	Woodlands Hill Seam	Lemington
C809 (GM/WDH)	MB	EX	314207	6395493	59.0	0.3	28.7	28.0	38.0	-	-	-	Woodlands Hill Seam	Lemington
D010(WDH)	MB	EX	314355	6395687	56.0	0.3	17.0	-	-	-	-	-	Woodlands Hill Seam	Lemington

Appendix B Groundwater quality

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
Appleyard Farm	29/02/2016	6.8	278																					
Appleyard Farm	31/05/2016	7	351																					
Appleyard Farm	12/08/2016	7	341																					
Appleyard Farm	24/11/2016	6.7	293	0.007	56	<0.001	0.041	8		0	2.5		6.6		28				<0.001		6.7		268	<0.005
B334(BFS)	30/05/2016	7.3	4790																					
B334(BFS)	25/11/2016	7.3	4560																					
B425(WDH)	30/05/2016	7.5	8990																					
B425(WDH)	24/11/2016	7.5	7070	0.013	1839	0.002	0.19	93		0	110		100		1600				<0.001		4		3900	0.007
B631(BFS)	30/05/2016	6.7	12670																					
B631(BFS)	25/11/2016	6.7	12260																					
B631(WDH)	30/05/2016	6.9	11830																					
B631(WDH)	25/11/2016	6.8	11710																					
B925(BFS)	30/05/2016	7	4580																					
B925(BFS)	24/11/2016	6.9	4260	0.58	1051	<0.001	0.14	15		0	12		13		930				0.001		1.2		2140	0.077
BC1a	5/02/2016	7.2	880																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
BC1a	26/05/2016	6.9	905																					
BC1a	1/09/2016	7.1	884																					
BC1a	10/11/2016	7.1	897																					
BUNC45A	26/02/2016	6.8	2020																					
BUNC45A	25/05/2016	6.8	1947																					
BUNC45A	1/09/2016	6.8	1990	6.7	539	0.005	0.093	57			7		37		340				0.004		54		1120	0.3
BUNC45A	10/11/2016	6.7	1970																					
BUNC45D	26/02/2016	6.7	2410																					
BUNC45D	25/05/2016	6.7	2400																					
BUNC45D	1/09/2016	6.6	2360	0.056	788	0.001	0.14	71			11		53		390				0.001		1		1400	0.022
BUNC45D	10/11/2016	6.7	2530																					
BZ1-1	25/02/2016	7.1	5950																					
BZ1-1	26/05/2016	7.1	5130																					
BZ1-1	1/09/2016	7.4	4870	3.2	752	0.005	0.094	40			17		98		820				0.004		140		2890	0.19
BZ1-1	10/11/2016	7.3	4360																					
BZ1-3	25/02/2016	7.1	1550																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
BZ1-3	26/05/2016	7.1	1497																					
BZ1-3	1/09/2016	7.2	1381	1.7	442	0.001	0.15	14			12		24		260				0.002		36		796	0.24
BZ1-3	10/11/2016	7.2	1418																					
BZ2A(1)	5/02/2016	6.4	1890																					
BZ2A(1)	26/05/2016	6.5	2700																					
BZ2A(1)	1/09/2016	6.7	1911																					
BZ2A(1)	10/11/2016	6.6	2900																					
BZ3-1	5/02/2016	7.8	1690																					
BZ3-1	26/05/2016	7.4	1742																					
BZ3-1	1/09/2016	7.9	1503																					
BZ3-1	10/11/2016	7.8	1549																					
BZ3-3	1/09/2016	6.5	1133																					
BZ3-3	10/11/2016	6.5	1140																					
BZ4A(2)	5/02/2016	6.5	1330																					
BZ4A(2)	26/05/2016	6.4	1353																					
BZ4A(2)	1/09/2016	6.5	1243																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
BZ4A(2)	10/11/2016	6.3	962																					
BZ8-2	25/02/2016	7	2150																					
BZ8-2	26/05/2016	6.8	1693																					
BZ8-2	1/09/2016	7	1402	0.22	338	0.004	0.056	40			5.9		60		160				0.003		51		807	0.051
BZ8-2	10/11/2016	6.9	1303																					
C1(WJ039)	5/02/2016	7.1	8050																					
C122(BFS)	30/05/2016	12.6	12000																					
C122(WDH)	30/05/2016	7.6	13690																					
C122(WDH)	25/11/2016	7.5	13680																					
C130(AFS1)	30/05/2016	7.4	13110																					
C130(AFS1)	25/11/2016	7.4	12270	0.067	851	0.011	0.2	120		0	42		160		2300				<0.001		42		6660	0.019
C130(ALL)	29/02/2016	6.9	20600																					
C130(ALL)	30/05/2016	7	20900																					
C130(ALL)	12/08/2016	6.9	21400																					
C130(ALL)	25/11/2016	7	20300	4.6	913	0.006	0.054	240		0	69		650		3700				0.008		650		11970	0.23
C130(BFS)	30/05/2016	7.6	3870																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
C130(BFS)	24/11/2016	7.5	3920																					
C130(WDH)	30/05/2016	6.7	20200																					
C130(WDH)	24/11/2016	6.5	20000																					
C317(BFS)	31/05/2016	7	6570																					
C317(BFS)	25/11/2016	7.1	8320																					
C317(WDH)	31/05/2016	7.2	7620																					
C317(WDH)	25/11/2016	7.4	7640																					
C613(BFS)	31/05/2016	6.7	9290																					
C613(BFS)	25/11/2016	7.2	9040																					
C621(BFS)	30/05/2016	7.8	3110																					
C621(BFS)	25/11/2016	7.6	3250																					
C630(BFS)	30/05/2016	7.9	3040																					
C630(BFS)	24/11/2016	7.8	3160																					
C809 (GM/WDH)	31/05/2016	6.9	9520																					
C809 (GM/WDH)	25/11/2016	7.1	9230																					
C919(ALL)	29/02/2016	7.3	774																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
C919(ALL)	30/05/2016	7.7	755																					
C919(ALL)	12/08/2016	7.6	790																					
C919(ALL)	25/11/2016	7.7	805	35	325	0.006	0.03	95		0	17		46		58				0.035		12		493	0.43
CHPZ10A	26/02/2016	7.1	691																					
CHPZ10A	26/05/2016	7	499																					
CHPZ10A	1/09/2016	6.9	695	0.005	205	0.001	0.039	50			0.9		31		41				0.001		25		387	0.005
CHPZ10A	10/11/2016	7	547																					
CHPZ11A	26/02/2016	6.8	1379																					
CHPZ12A	25/02/2016	7	753																					
CHPZ12A	26/05/2016	6.9	803																					
CHPZ12A	30/08/2016	6.8	721	0.005	216	0.001	0.045	52			0.8		33		40				0.003		30		404	0.005
CHPZ12A	10/11/2016	7	719																					
CHPZ12D	25/02/2016	6.9	1356																					
CHPZ12D	26/05/2016	6.9	1273																					
CHPZ12D	30/08/2016	6.8	1300	0.005	530	0.001	0.13	17			8		12		260				0.001		1		703	0.007
CHPZ12D	10/11/2016	7.1	1349																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CHPZ14A	24/02/2016	7	740																					
CHPZ14D	24/02/2016	7.2	992																					
CHPZ1A	26/02/2016	7.1	820																					
CHPZ1A	26/05/2016	7.4	871																					
CHPZ1A	31/08/2016	7	818	0.021	213	0.001	0.029	52	0.005		2.1	0.005	34	0.002	63	0.01	0.07	0.003	0.001	24	27	490	504	0.005
CHPZ1A	10/11/2016	6.8	711																					
CHPZ2A	24/02/2016	7.1	899																					
CHPZ2A	26/05/2016	7.3	858																					
CHPZ2A	1/09/2016	7.1	874	0.005	228	0.001	0.038	46			0.9		36		85				0.001		45		513	0.023
CHPZ2A	10/11/2016	7.1	908																					
CHPZ3A	24/02/2016	7	659																					
CHPZ3A	26/05/2016	7	640																					
CHPZ3A	30/08/2016	6.9	710	0.059	174	0.001	0.038	39			0.9		30		50				0.001		27		352	0.005
CHPZ3A	10/11/2016	7.4	701																					
CHPZ3D	24/02/2016	6.8	1185																					
CHPZ3D	26/05/2016	6.8	1157																					

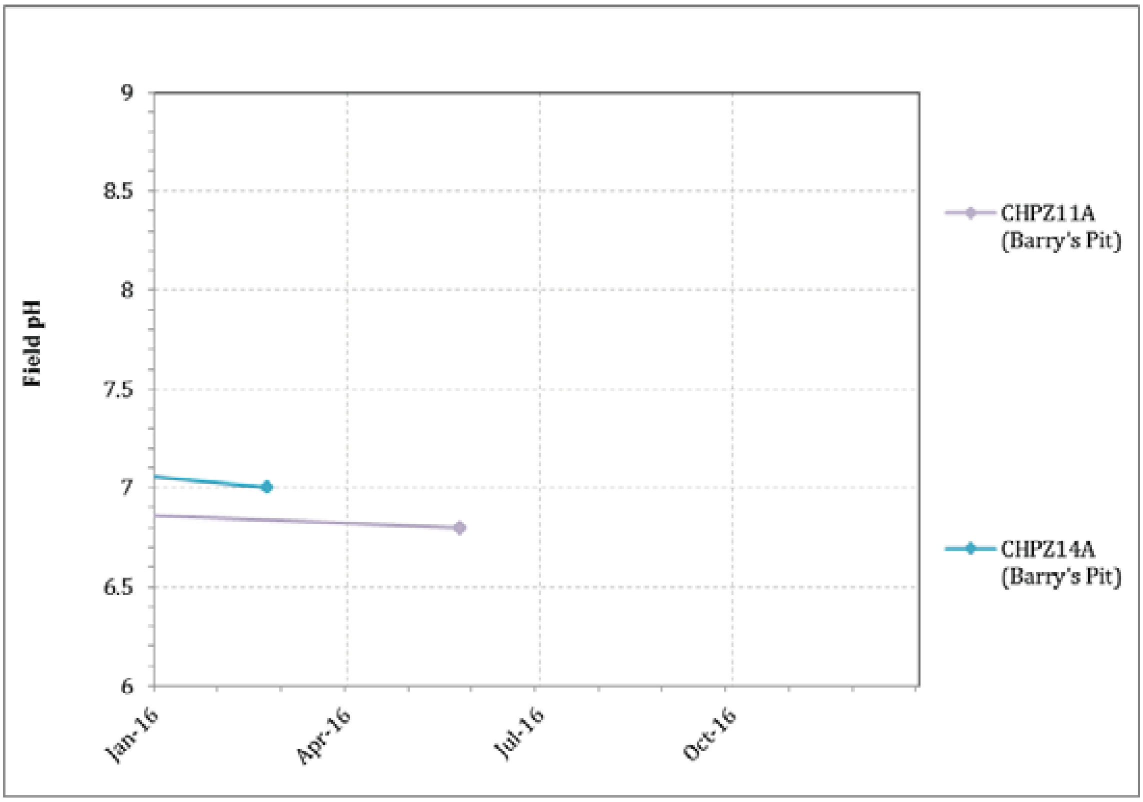
Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CHPZ3D	30/08/2016	6.6	1109	0.008	460	0.001	0.14	24			5.9		12		210				0.001		1		606	0.01
CHPZ3D	10/11/2016	6.7	1052																					
CHPZ4A	24/02/2016	7	740																					
CHPZ4A	26/05/2016	7.1	787																					
CHPZ4A	1/09/2016	7	783	0.005	206	0.001	0.033	42			1.4		43		100				0.001		43		436	0.02
CHPZ4A	10/11/2016	7	619																					
CHPZ8A	26/02/2016	6.8	1640																					
CHPZ8A	26/05/2016	7	1715																					
CHPZ8A	31/08/2016	7	1708			0.001																		
CHPZ8A	10/11/2016	7.1	1711																					
CHPZ8D	26/02/2016	7.2	1140																					
CHPZ8D	26/05/2016	7.1	1105																					
CHPZ8D	31/08/2016	7.2	1393	0.16	516	0.001	0.059	140			3.5		71		45				0.001		49		826	0.009
CHPZ8D	10/11/2016	7.1	1455																					
D010(BFS)	31/05/2016	7.1	10740																					
D010(BFS)	25/11/2016	7	10550																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
D010(GM)	31/05/2016	6.5	11040																					
D010(GM)	25/11/2016	6.8	11080	0.012	1195	<0.001	0.12	130		0	51		380		1900				<0.001		350		6180	<0.005
D010(WDH)	31/05/2016	6.9	9150																					
D010(WDH)	25/11/2016	7	9170																					
D214(BFS)	30/05/2016	7.8	7270																					
D214(BFS)	25/11/2016	7.7	7290																					
D317(ALL)	12/08/2016					0.001																		
D317(BFS)	30/05/2016	7.9	2970																					
D317(BFS)	12/08/2016					0.001																		
D317(BFS)	24/11/2016	8.6	3060																					
D406(AFS)	30/05/2016	6.9	11920																					
D406(AFS)	25/11/2016	6.8	11950																					
D406(BFS)	30/05/2016	7.3	6830																					
D406(BFS)	25/11/2016	7.3	6920																					
D510(AFS)	30/05/2016	7	13870																					
D510(AFS)	25/11/2016	7	13900																					

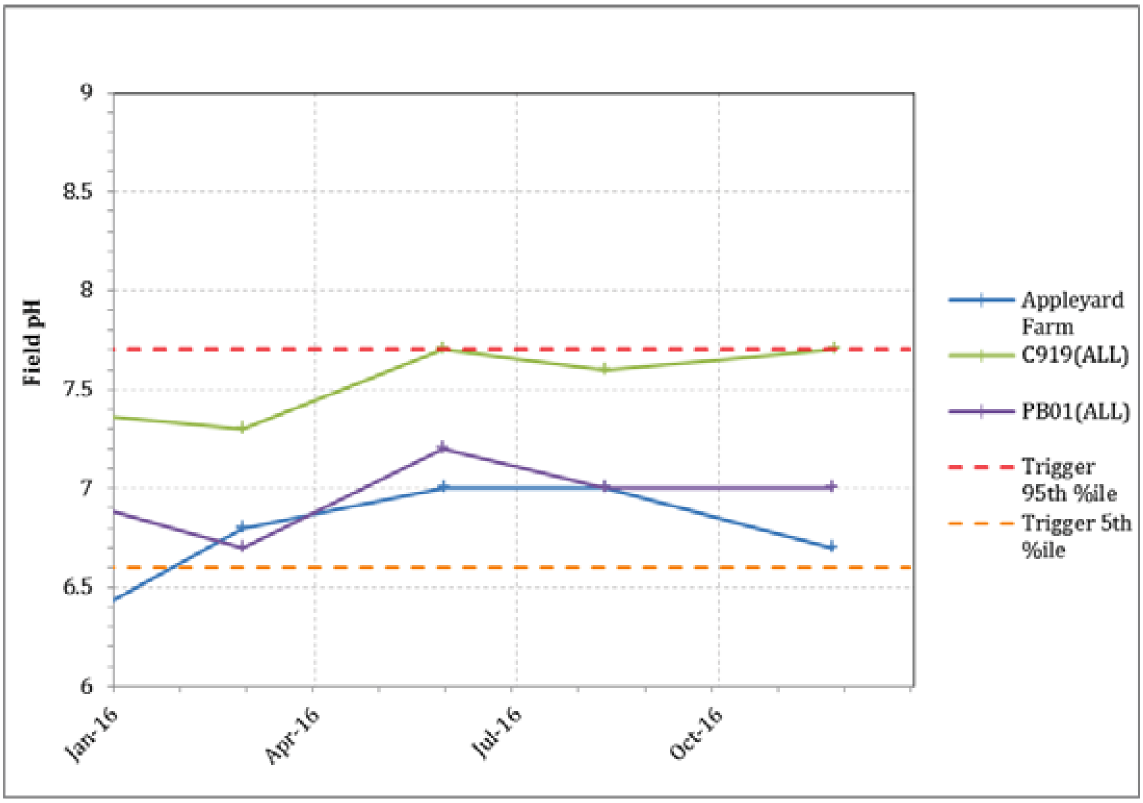
Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
D510(BFS)	30/05/2016	7.5	12480																					
D510(BFS)	25/11/2016	7.4	12390																					
D612(AFS)	30/05/2016	6.9	15100																					
D612(AFS)	25/11/2016	6.7	15170																					
D612(BFS)	30/05/2016	7	11240																					
D612(BFS)	25/11/2016	7	11340																					
D807(BFS)	31/05/2016	6.6	9940																					
D807(BFS)	25/11/2016	7	9760																					
HG2	5/02/2016	6.9	5080																					
HG2	26/05/2016	6.7	4820																					
HG2	1/09/2016	7	4810			0.001																		
HG2	10/11/2016	6.9	4750																					
HG2A	5/02/2016	7	1388																					
HG2A	26/05/2016	6.9	1361																					
HG2A	1/09/2016	7.1	1428			0.001																		
HG2A	10/11/2016	6.9	1487																					

Station	Date	pH Field	EC Field (uS/cm)	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B mg/l)	Ca - Total (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Rb - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
Hobdens Well	5/02/2016	7.5	1036																					
Hobdens Well	26/05/2016	7.4	980																					
Hobdens Well	1/09/2016	7.6	985	0.005	268	0.001	0.033	42			1.4		43		100				0.001		43		522	0.02
Hobdens Well	10/11/2016	7.7	1022																					
LUG Bore	29/02/2016	7.6	8730																					
LUG Bore	31/05/2016	7.1	8330																					
LUG Bore	12/08/2016	7.5	8690			0.001																		
PB01(ALL)	29/02/2016	6.7	1892																					
PB01(ALL)	30/05/2016	7.2	2350																					
PB01(ALL)	12/08/2016	7	2300																					
PB01(ALL)	24/11/2016	7	4510	0.014	337	<0.001	0.13	73		0	16		140		610				0.004		130		2520	<0.005

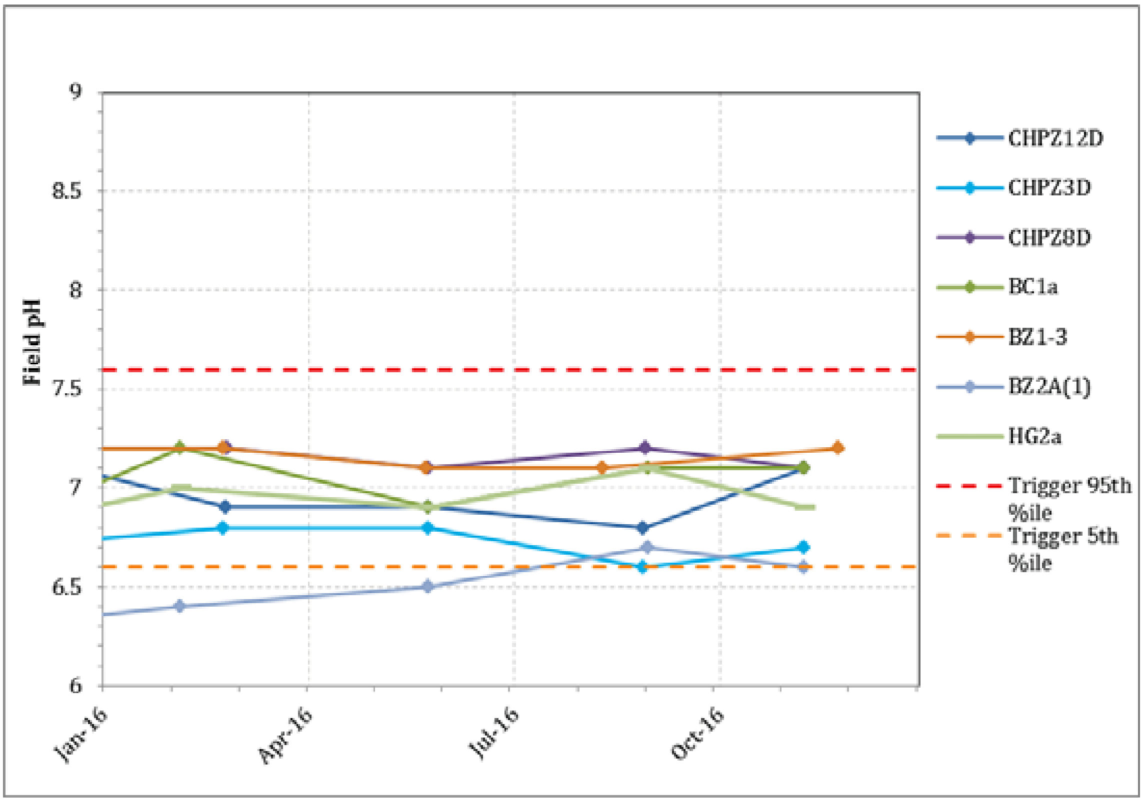
2016 Field pH



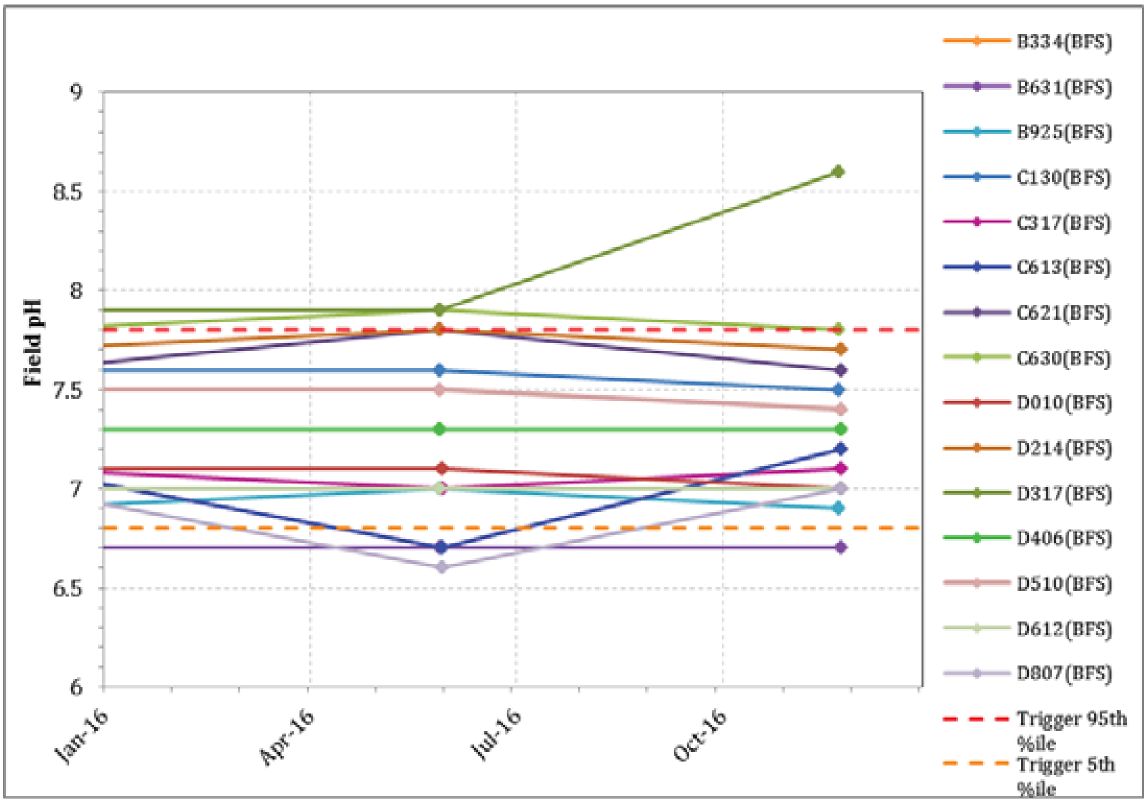
Alluvium (no trigger level)



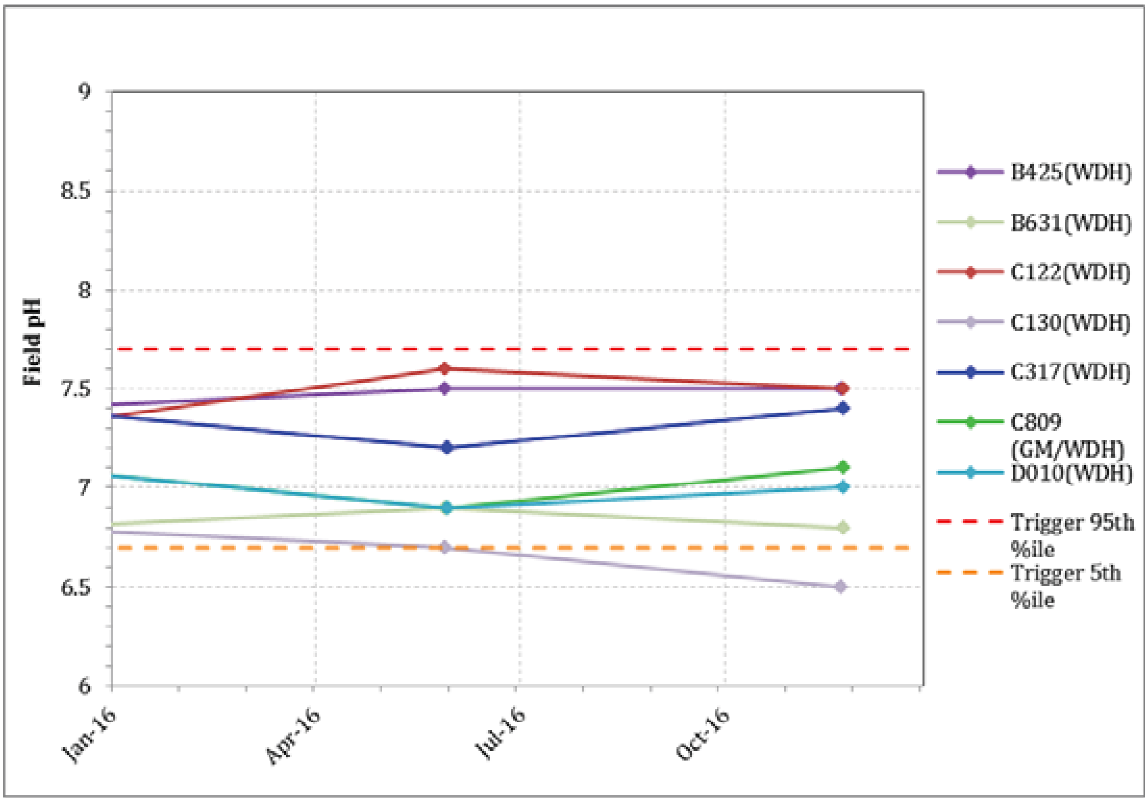
Lemington – Alluvium



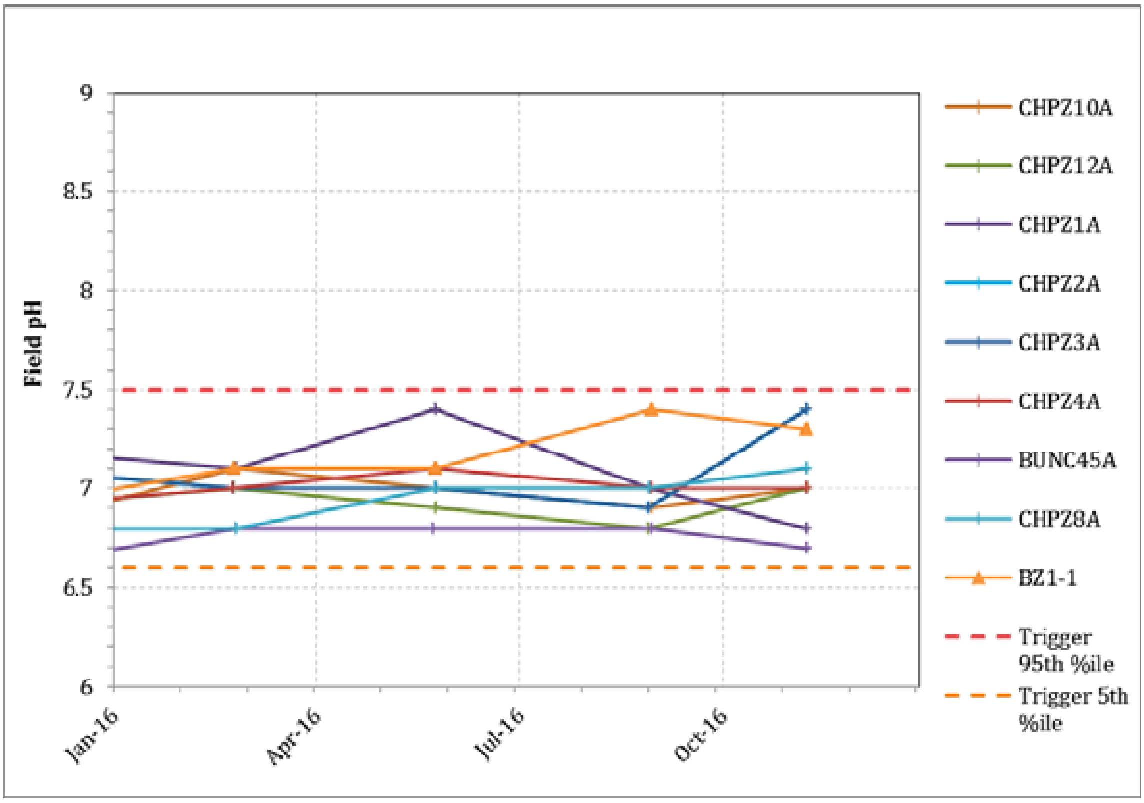
Barry's Pit / Cheshunt – Mt Arthur Seam



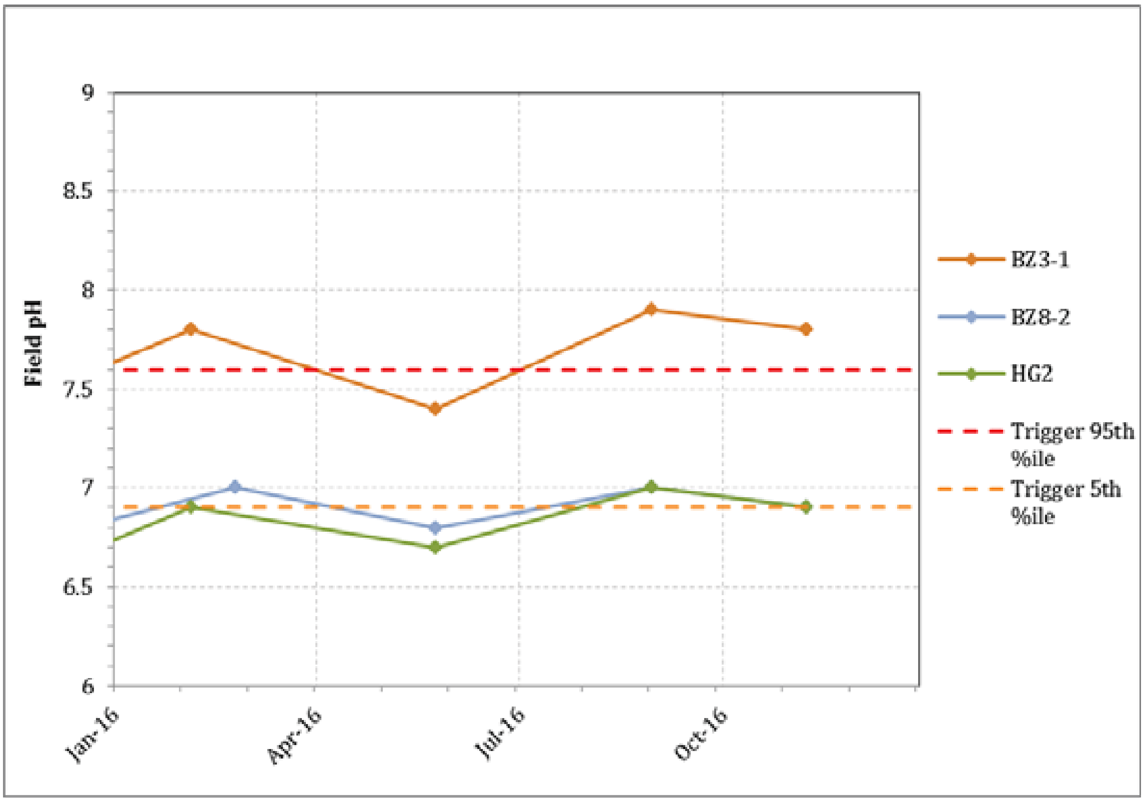
Lemington – Bowfield Seam



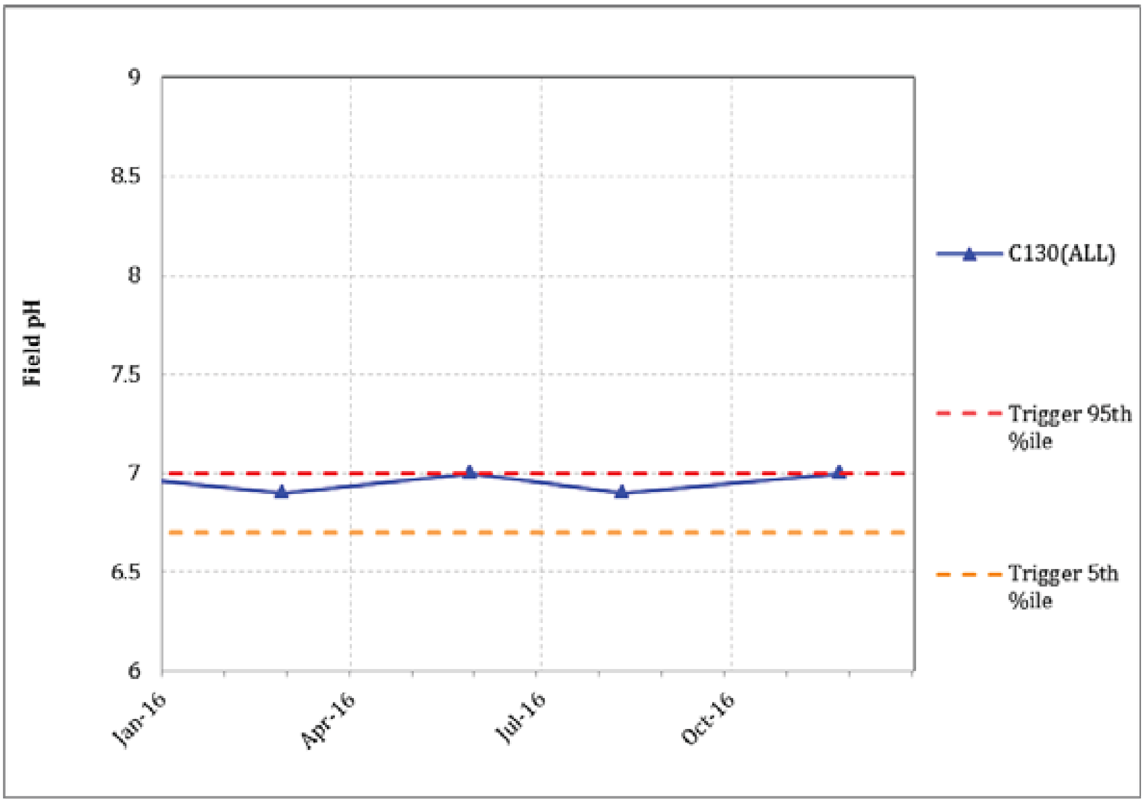
Lemington – Woodlands Hill Seam



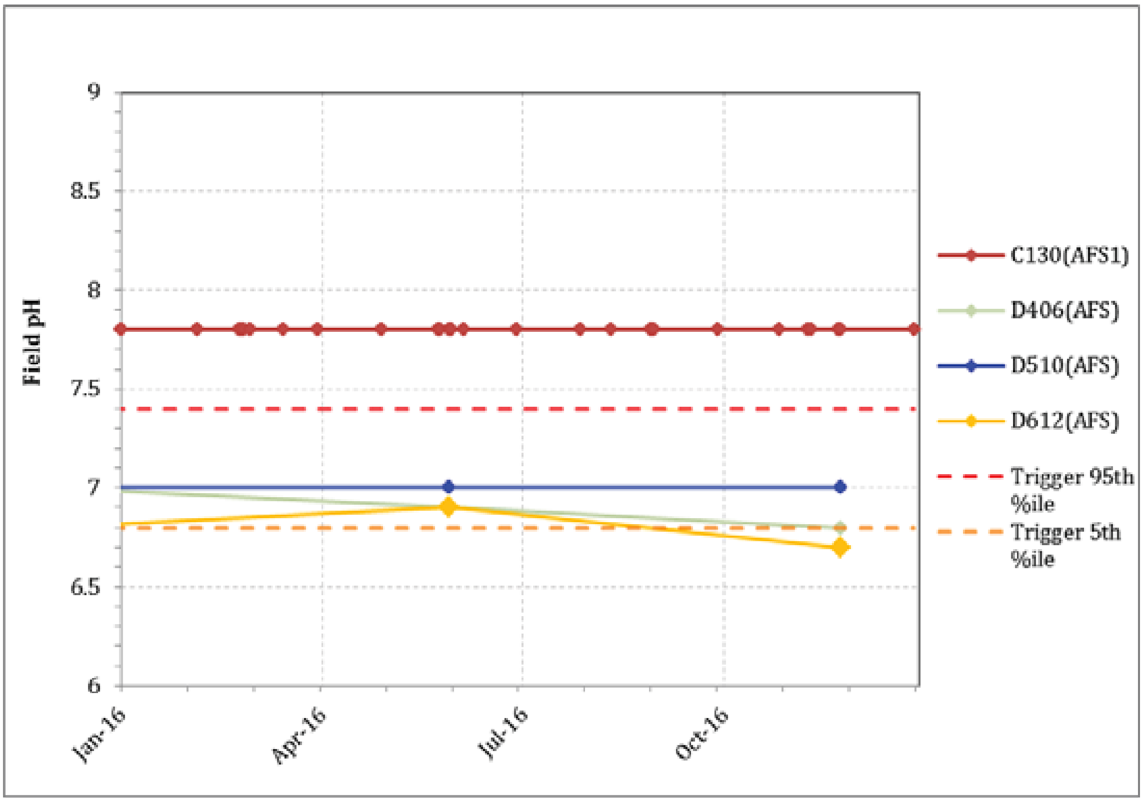
Barry's Pit – Alluvium / regolith & interburden



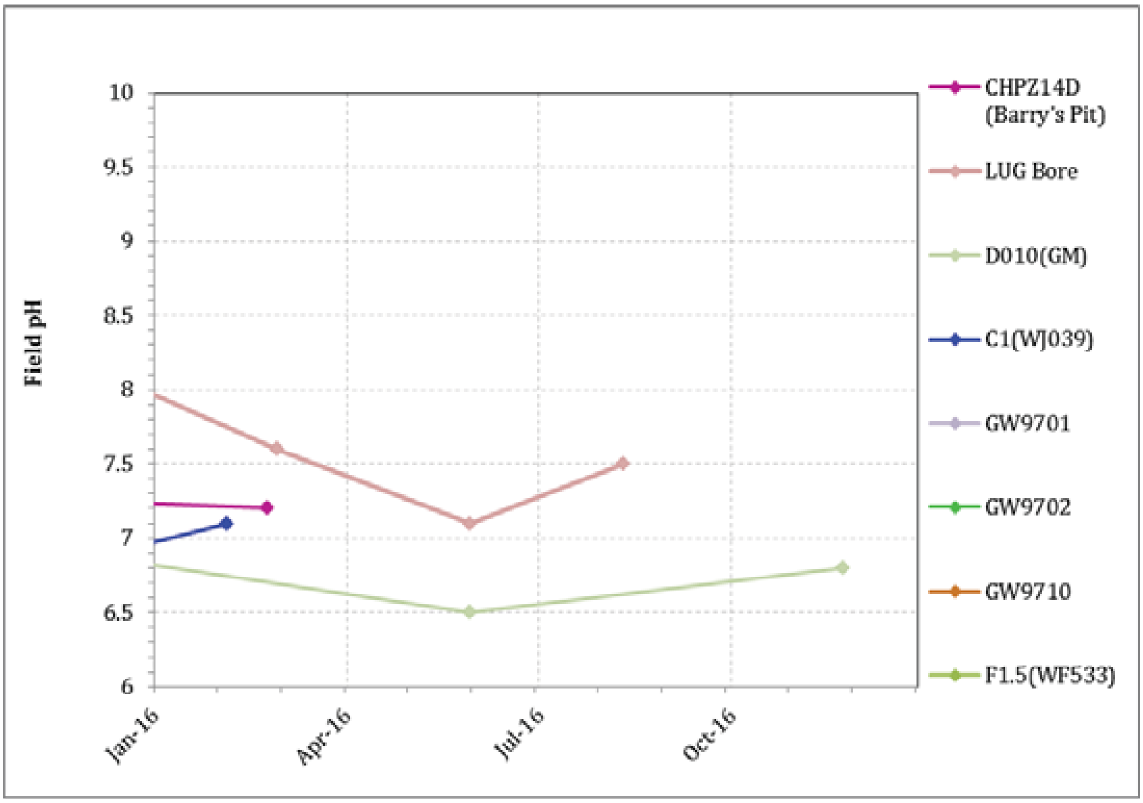
Cheshunt – Interburden



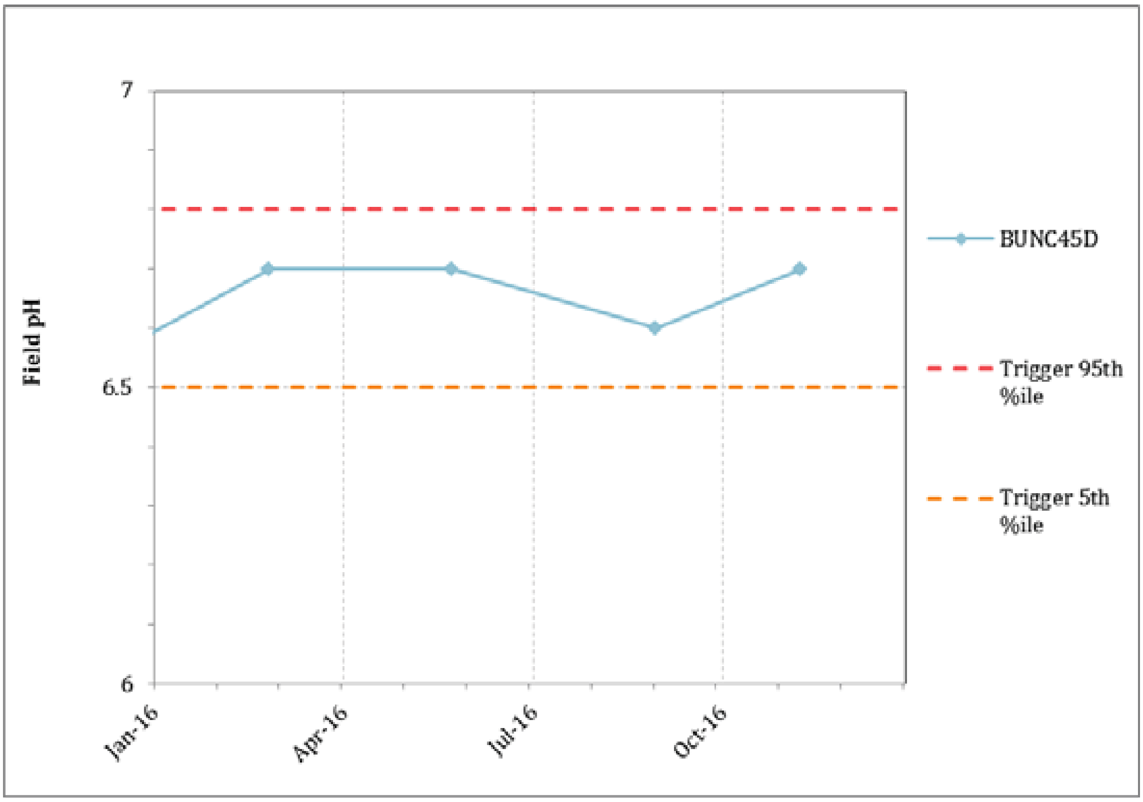
Lemington – Interburden



Lemington – Arrowfield Seam

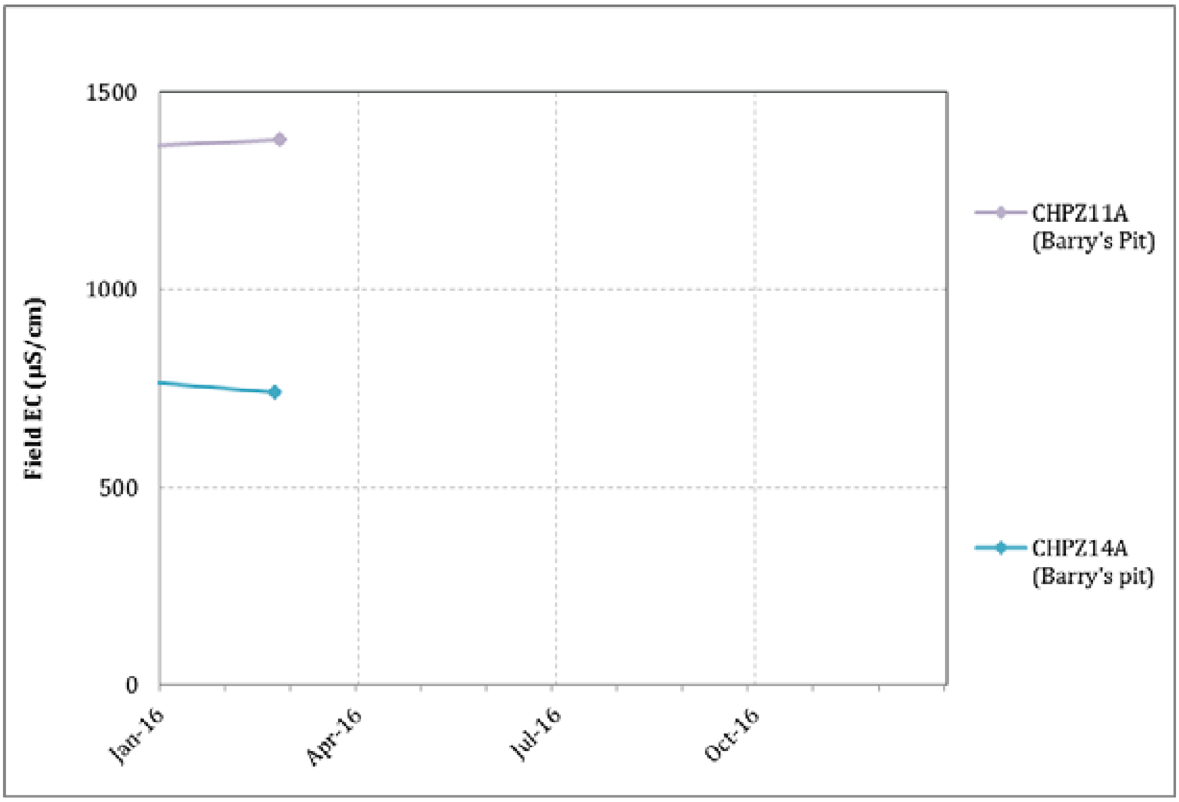


Barry's Pit / Cheshunt / Lemington – Coal measures (no trigger level)

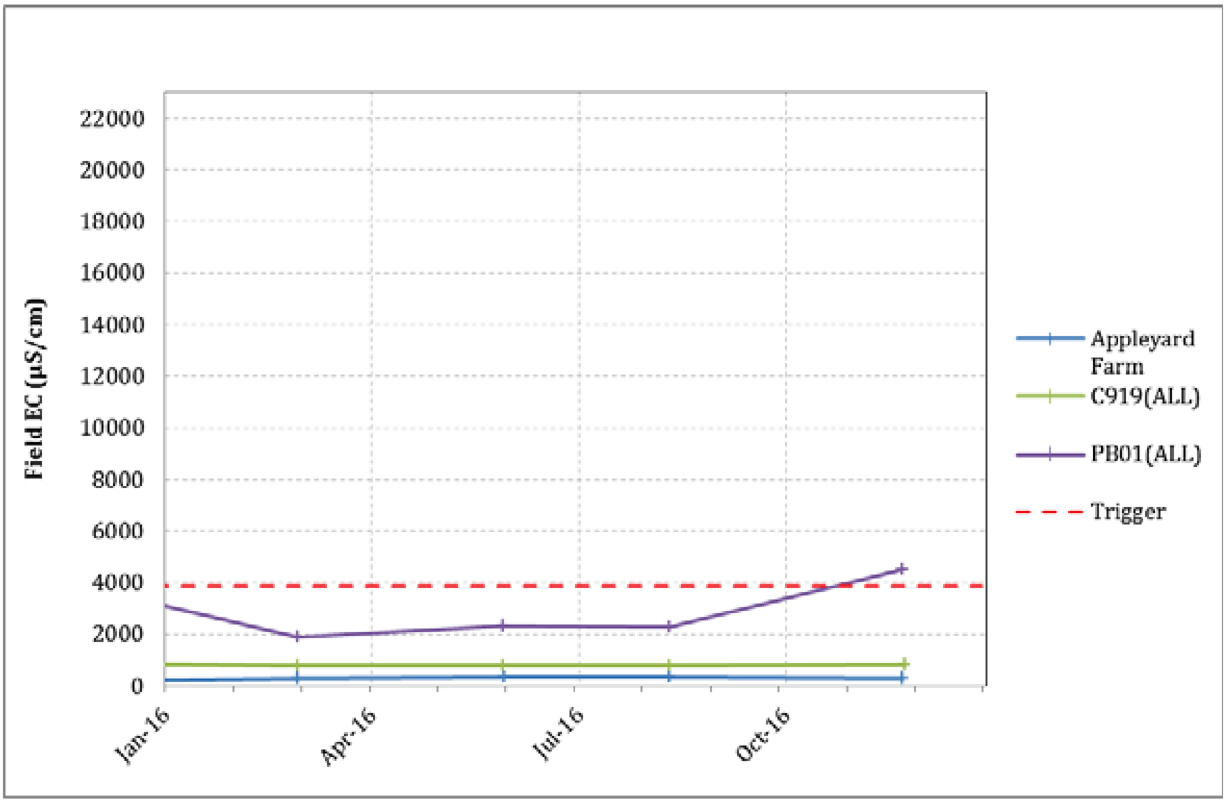


Barry's Pit – Mt Arthur Seam

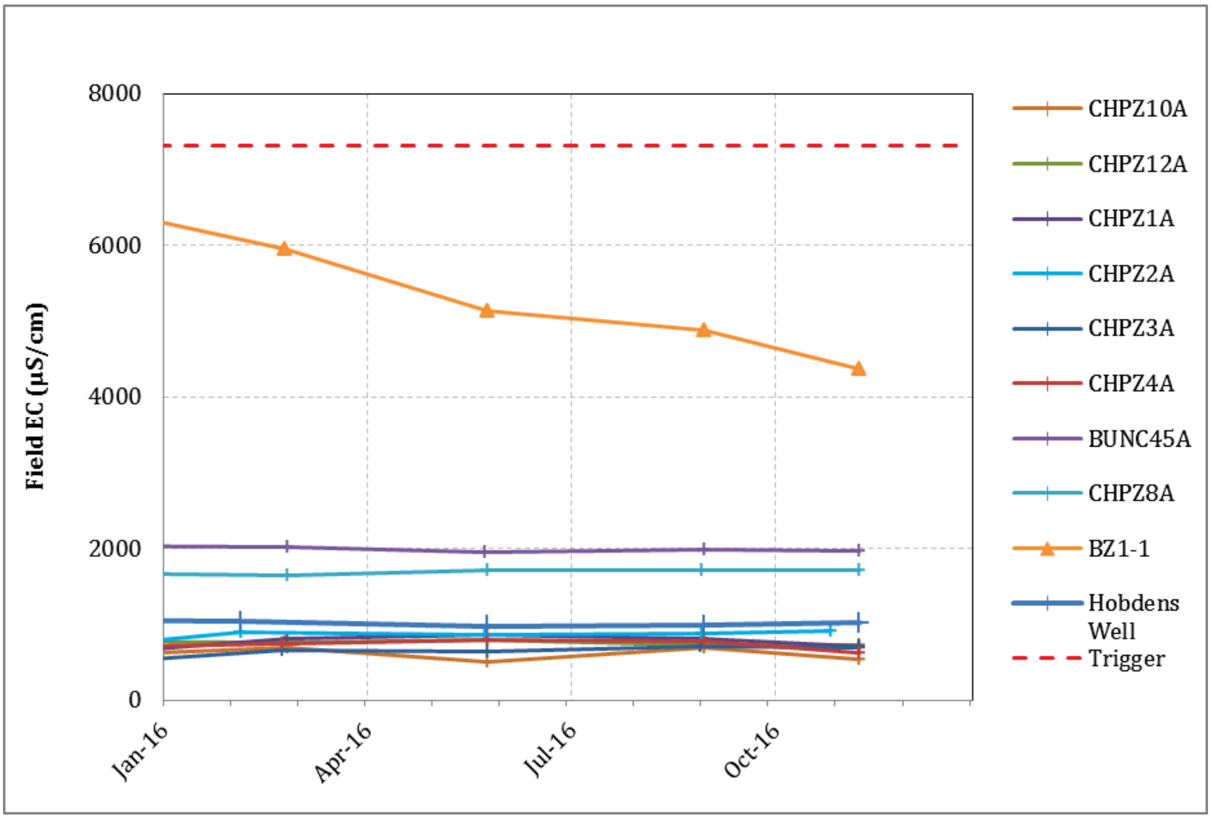
2016 Field EC



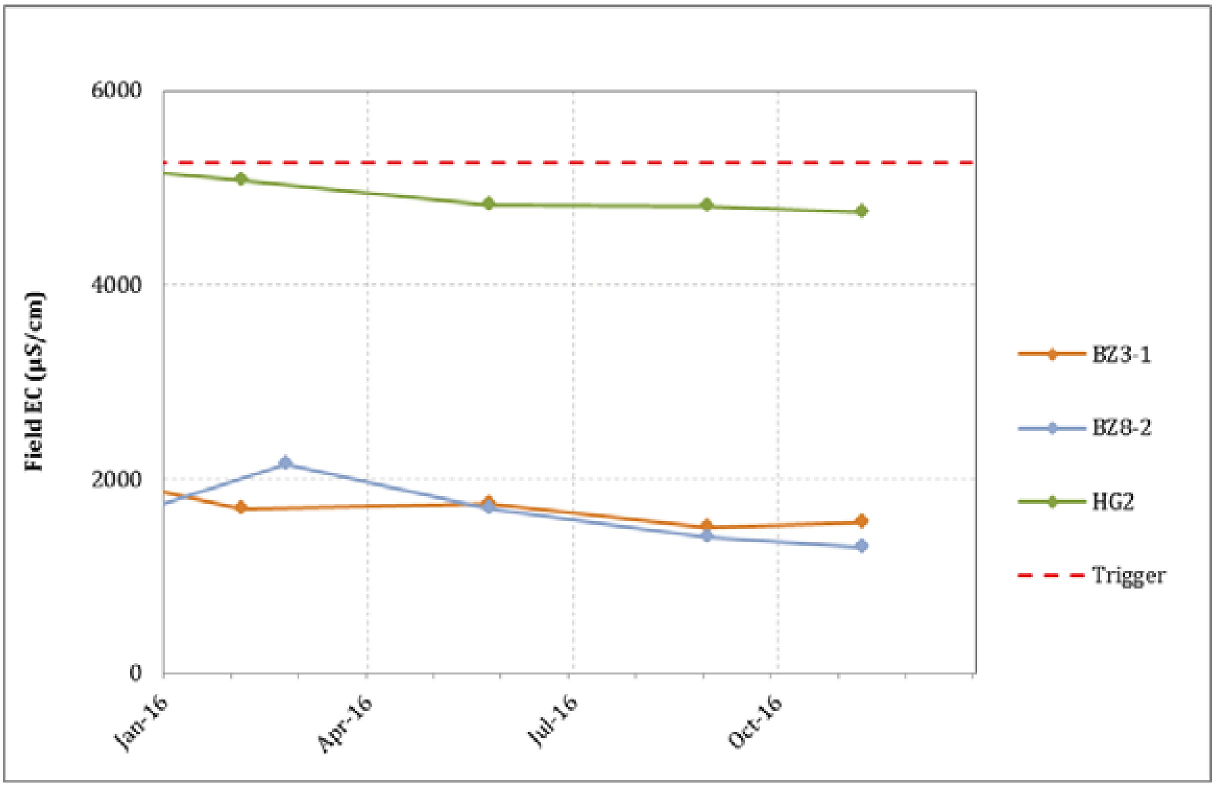
Alluvium (No Trigger level)



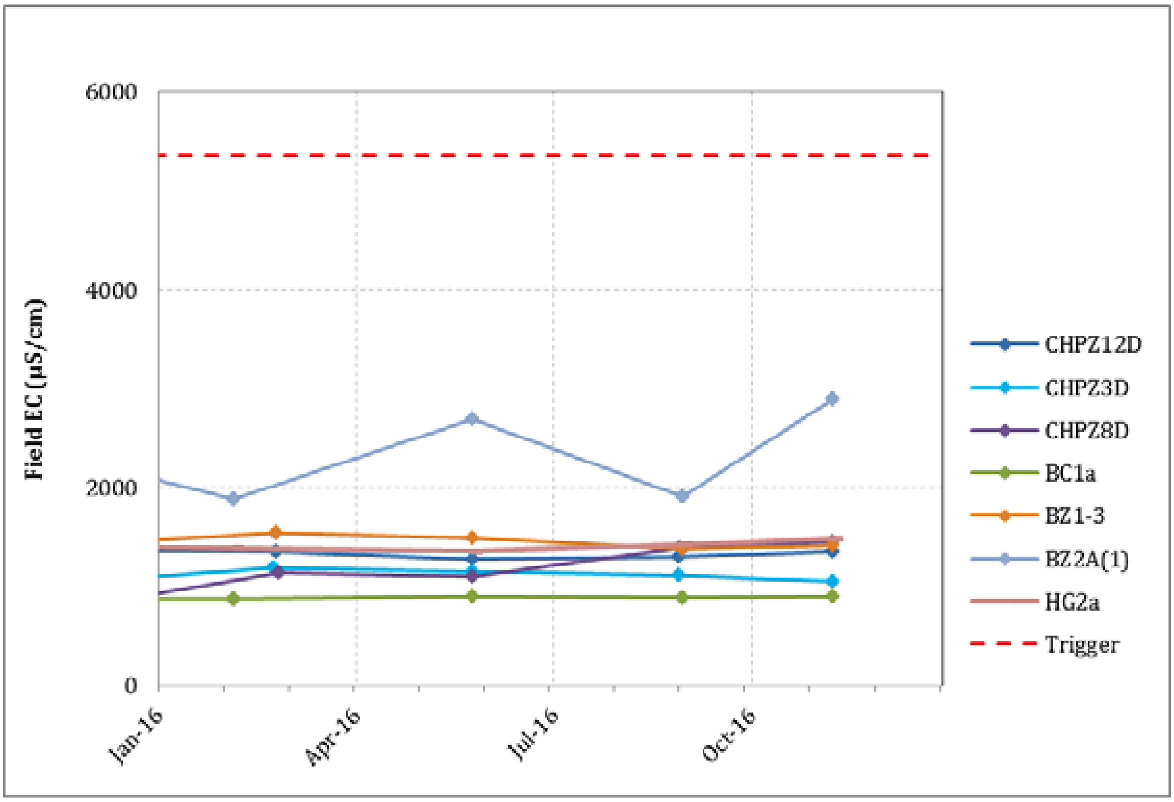
Lemington – Alluvium



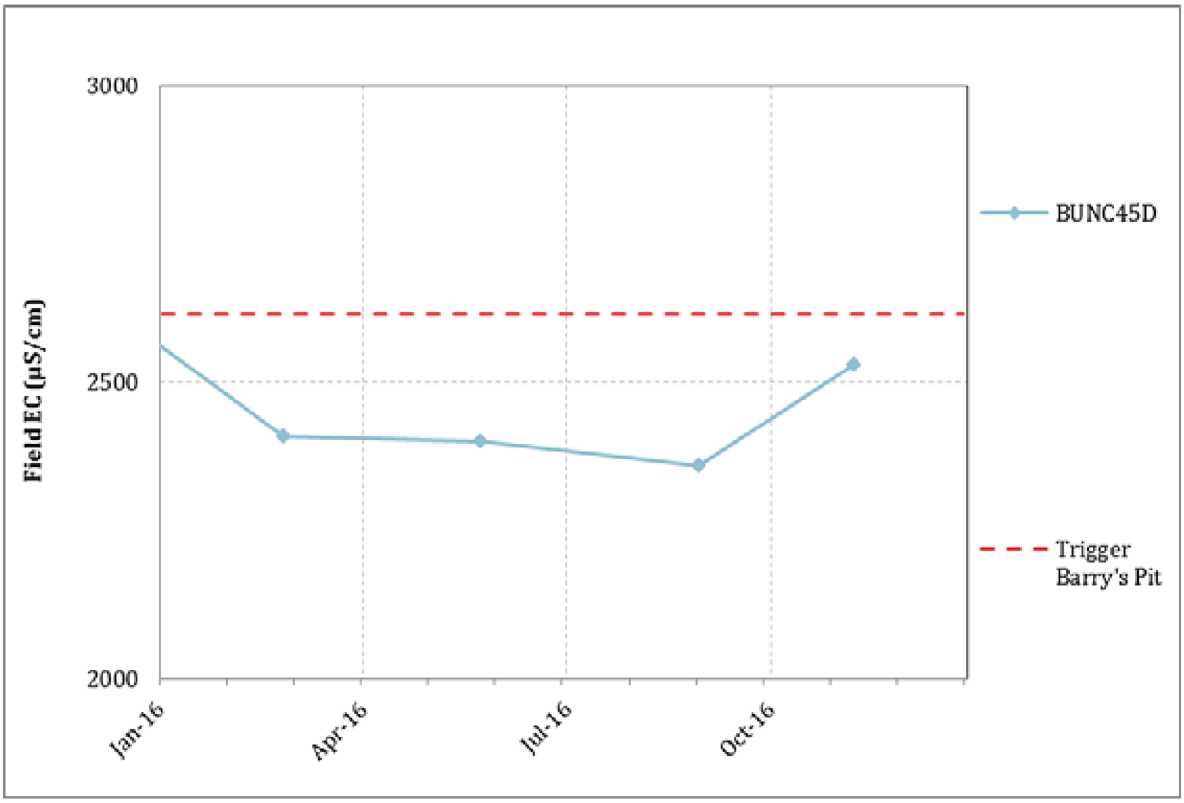
Cheshunt Pit northern area – Alluvium / regolith & interburden



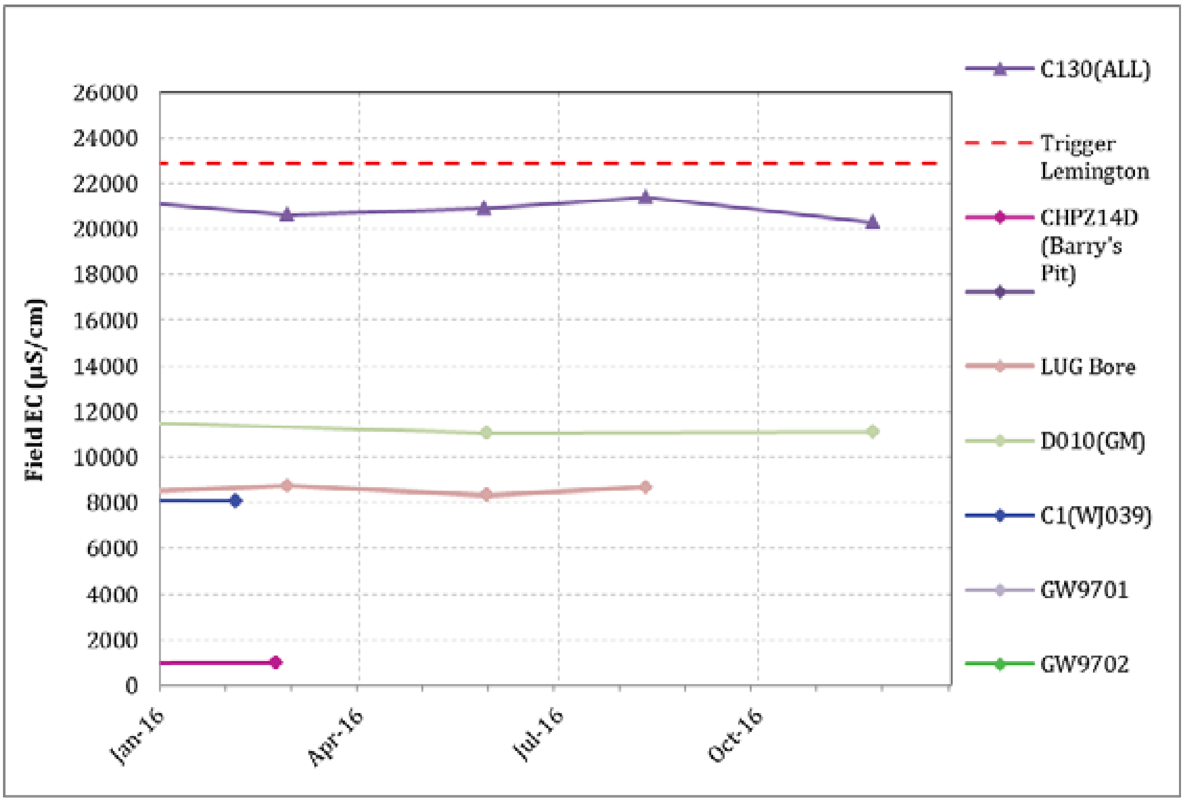
Cheshunt – Interburden



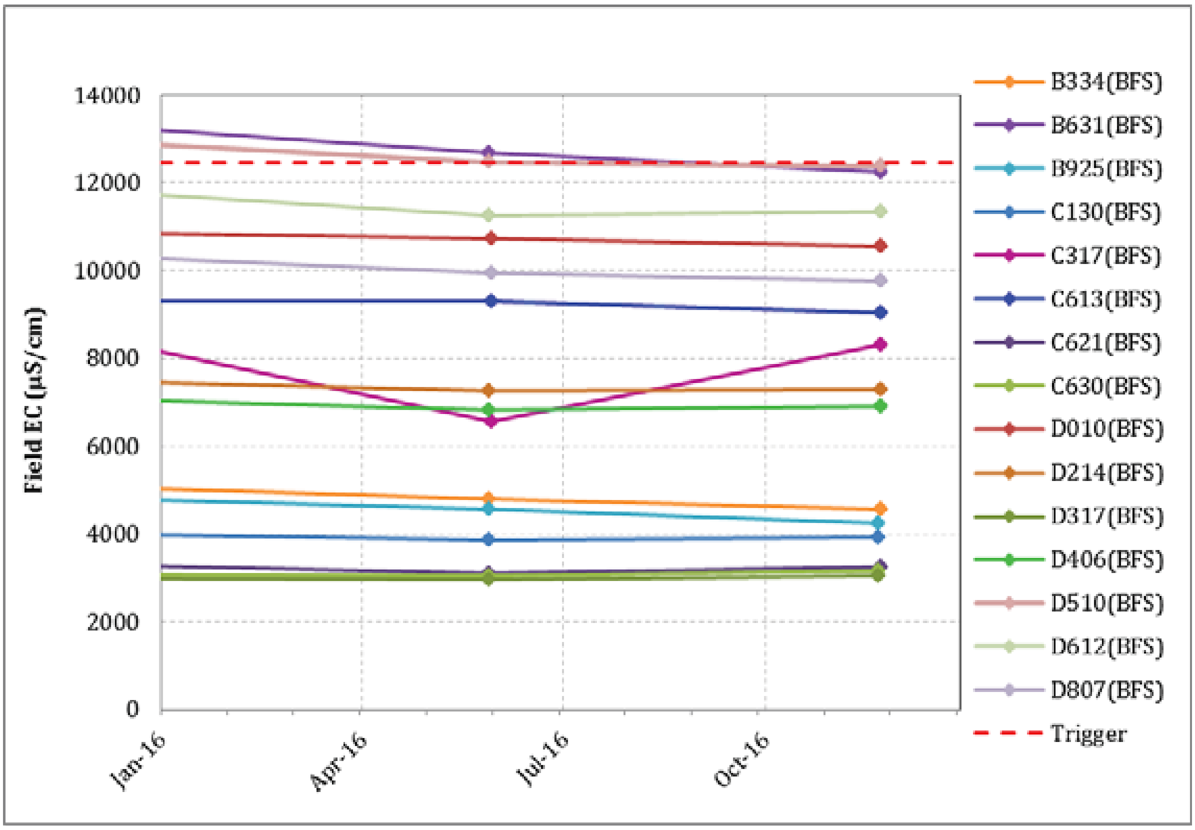
Barry's Pit / Cheshunt Pit – Mt Arthur Seam



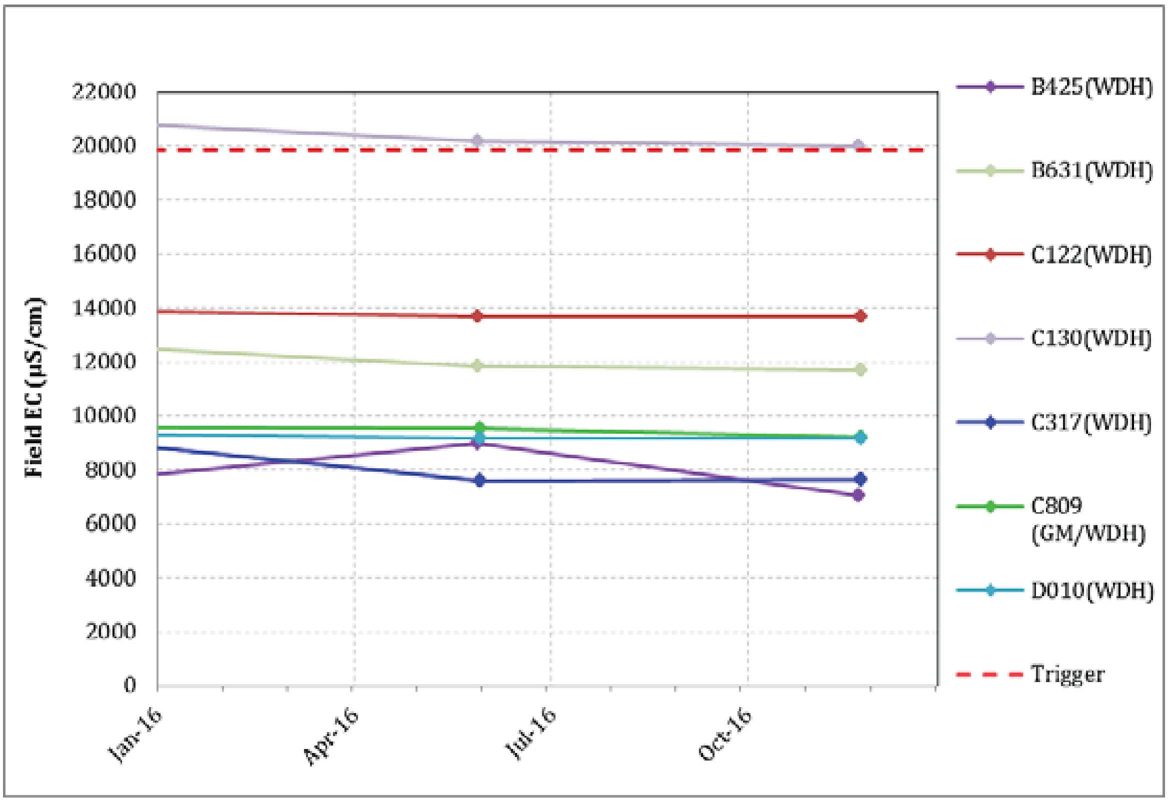
Barry's Pit – Mt Arthur Seam



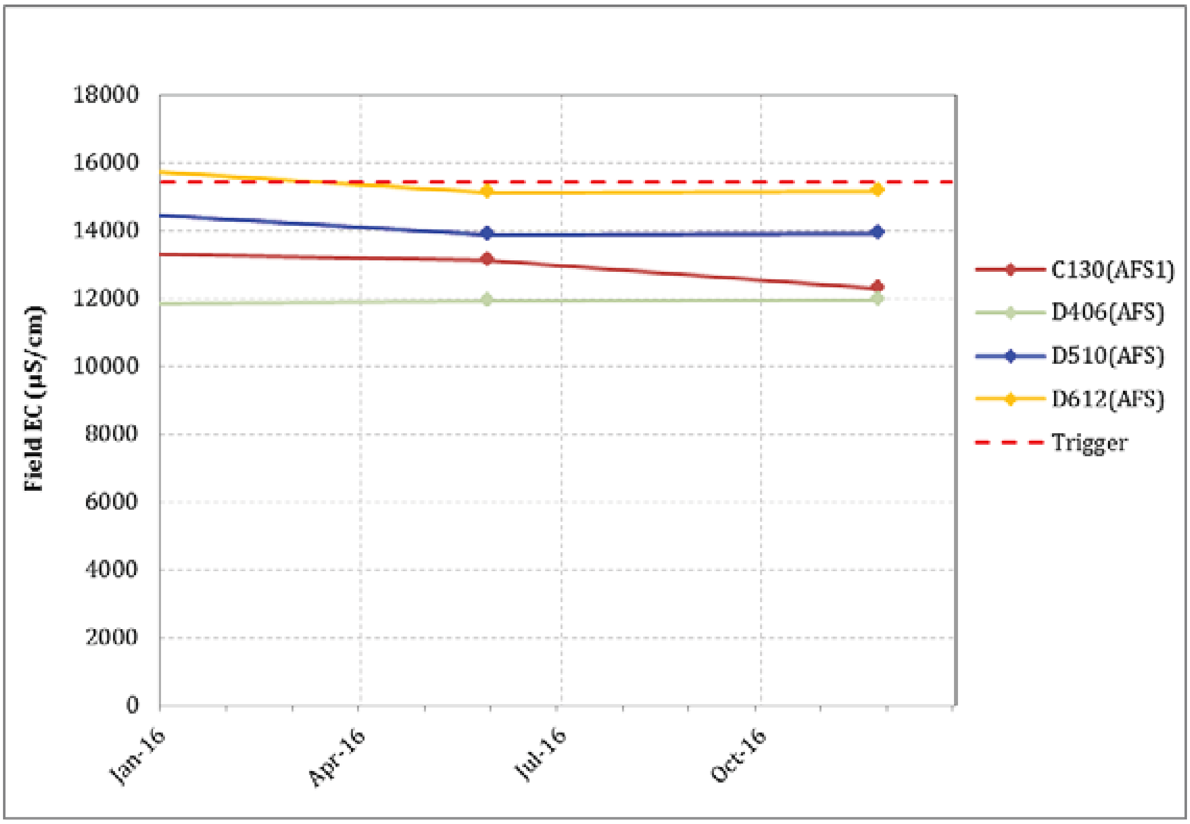
Lemington – Interburden



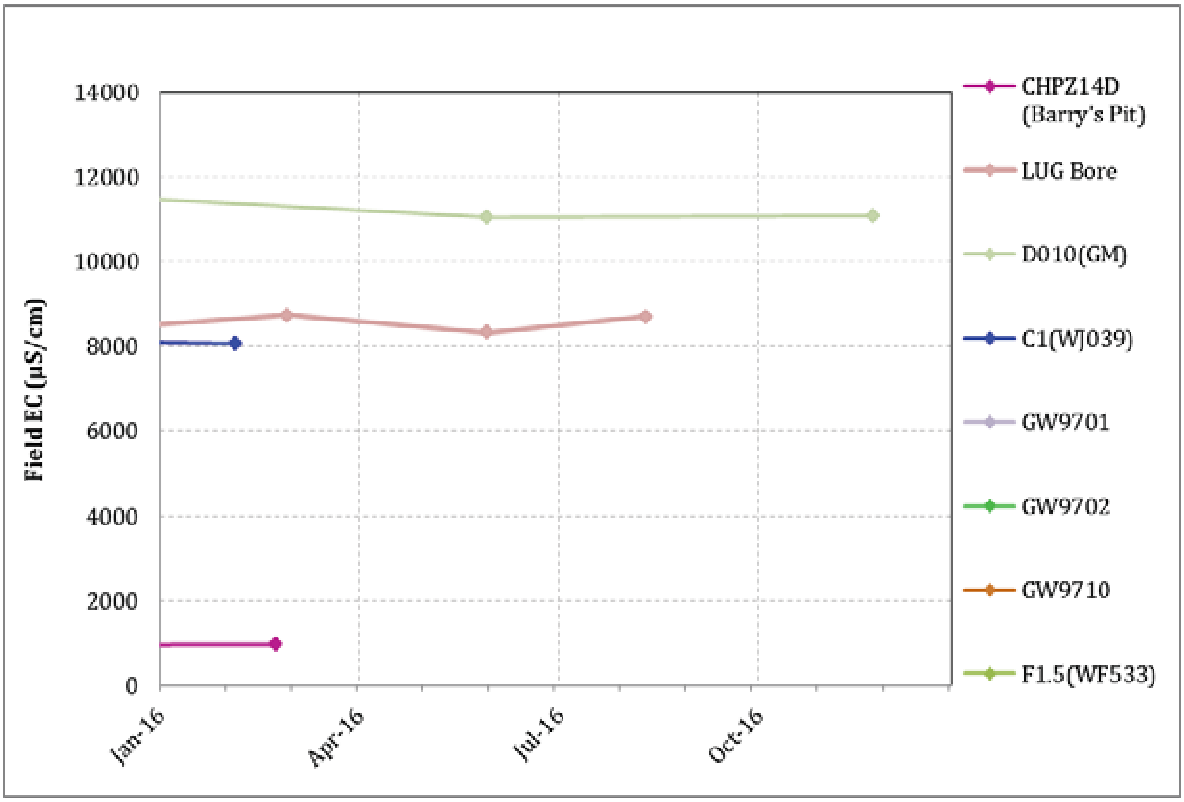
Lemington – Bowfield Seam



Lemington – Woodlands Hill Seam



Lemington – Arrowfield Seam



Barry's Pit / Cheshunt / Lemington – Coal measures (no trigger level)

Appendix C **Hydrographs**

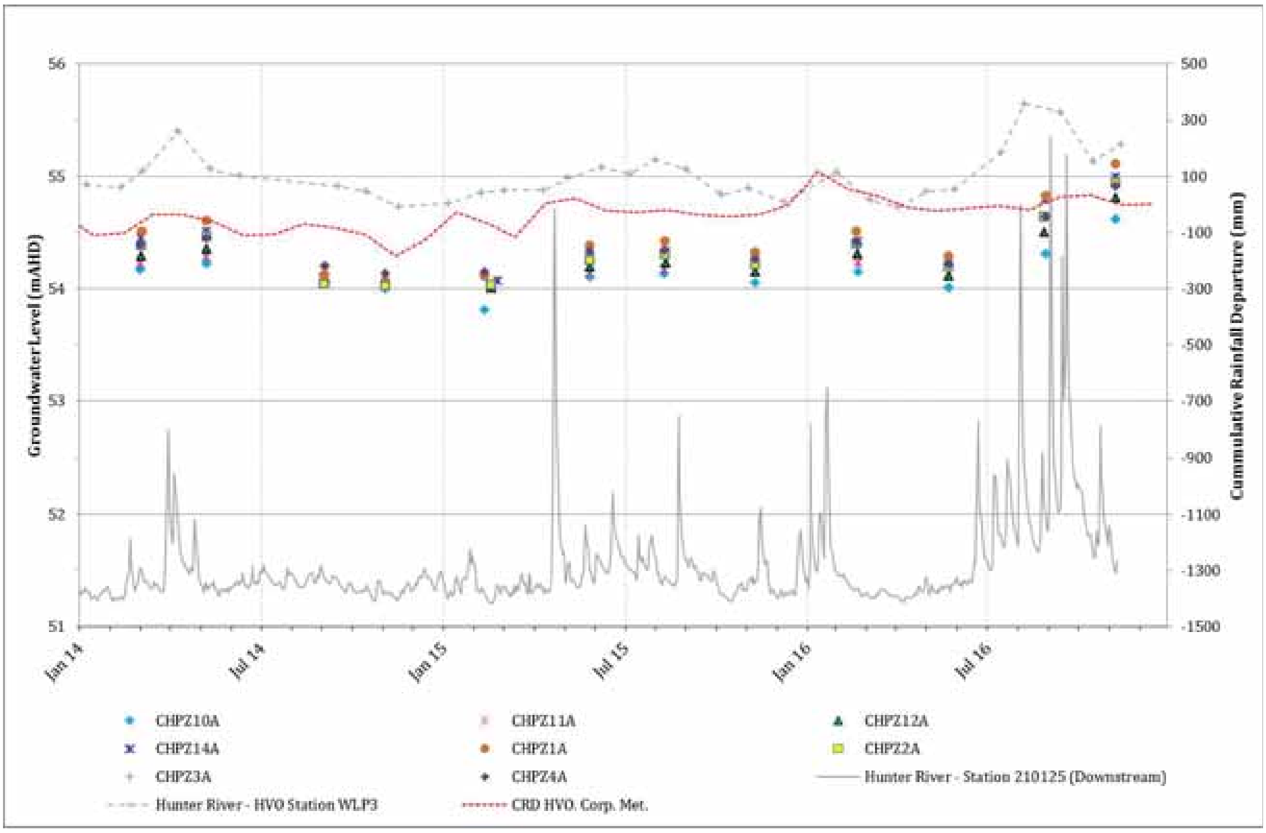


Figure C.1 Barry's Pit / Cheshunt area - Alluvium

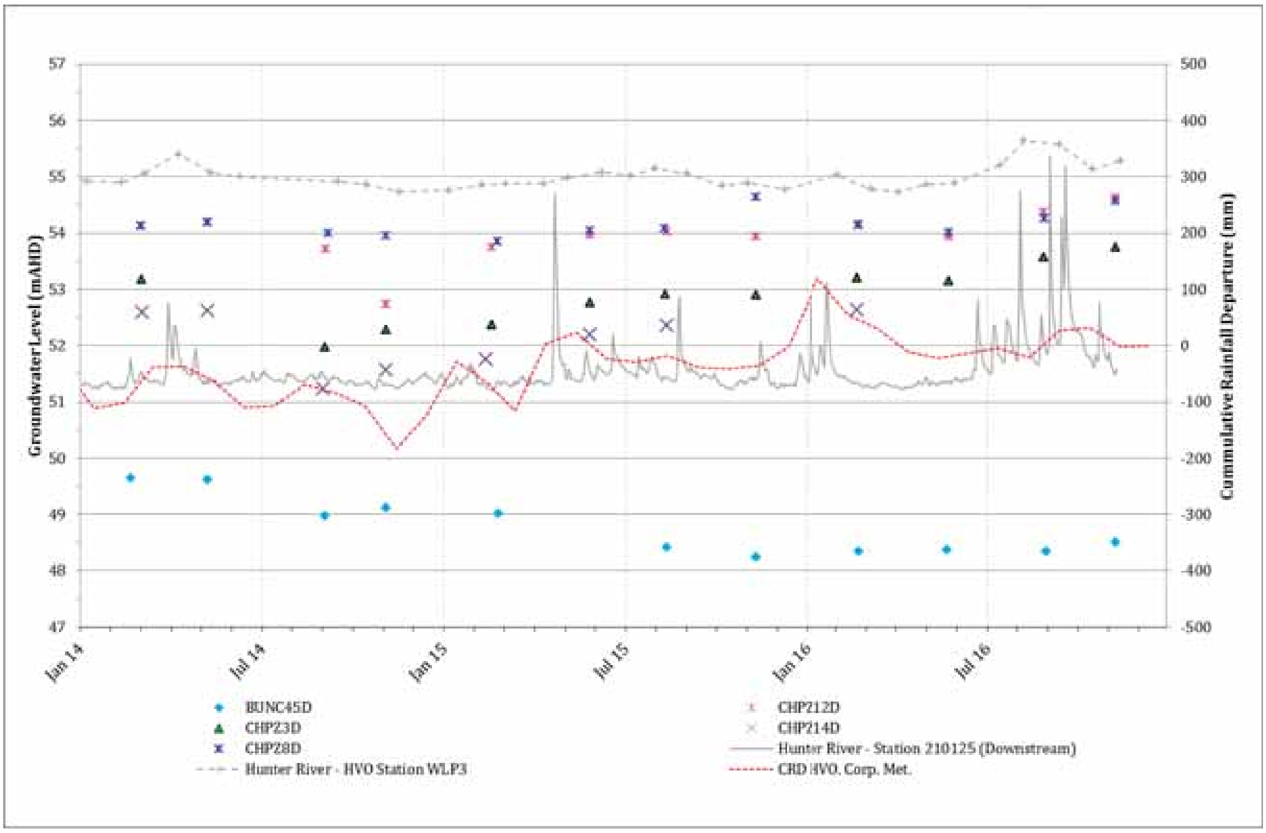


Figure C.2 Cheshunt – Mount Arthur Seam

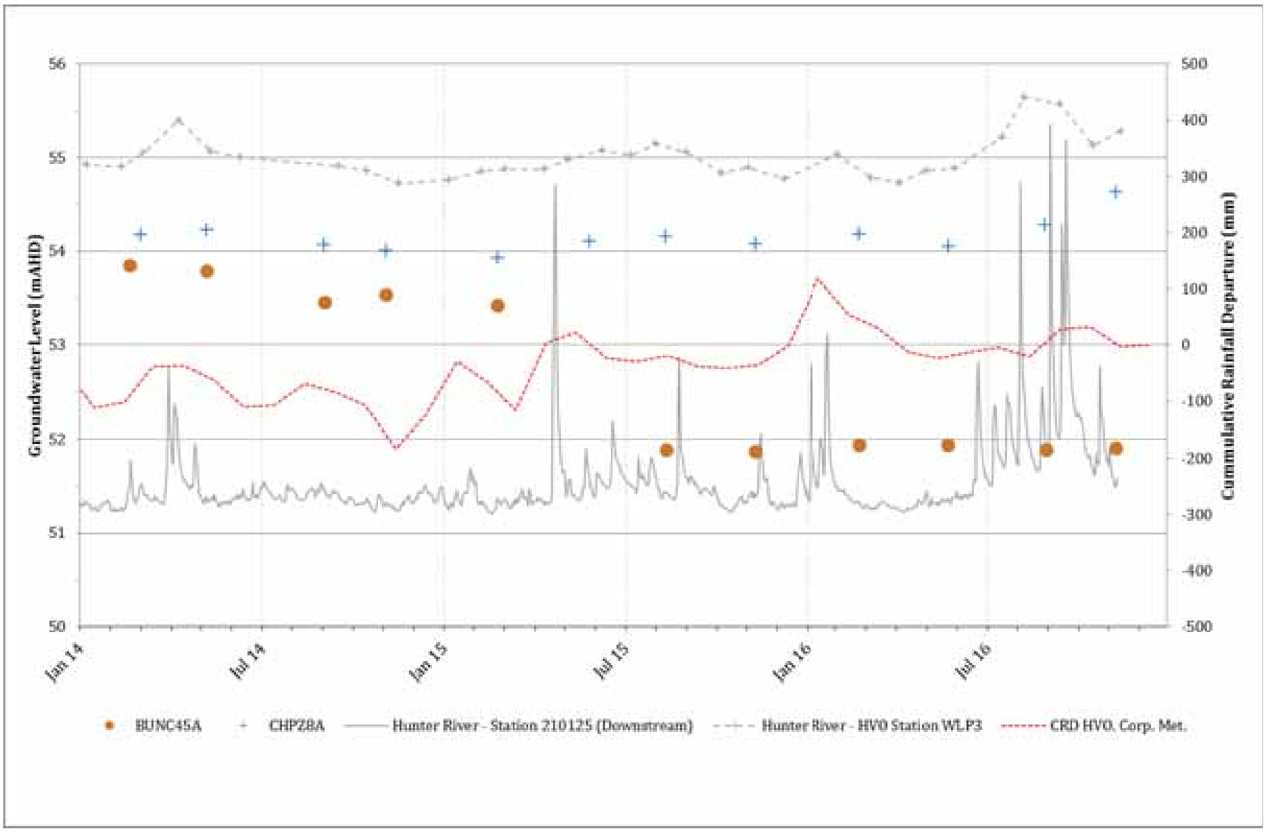


Figure C.3 Cheshunt - Regolith

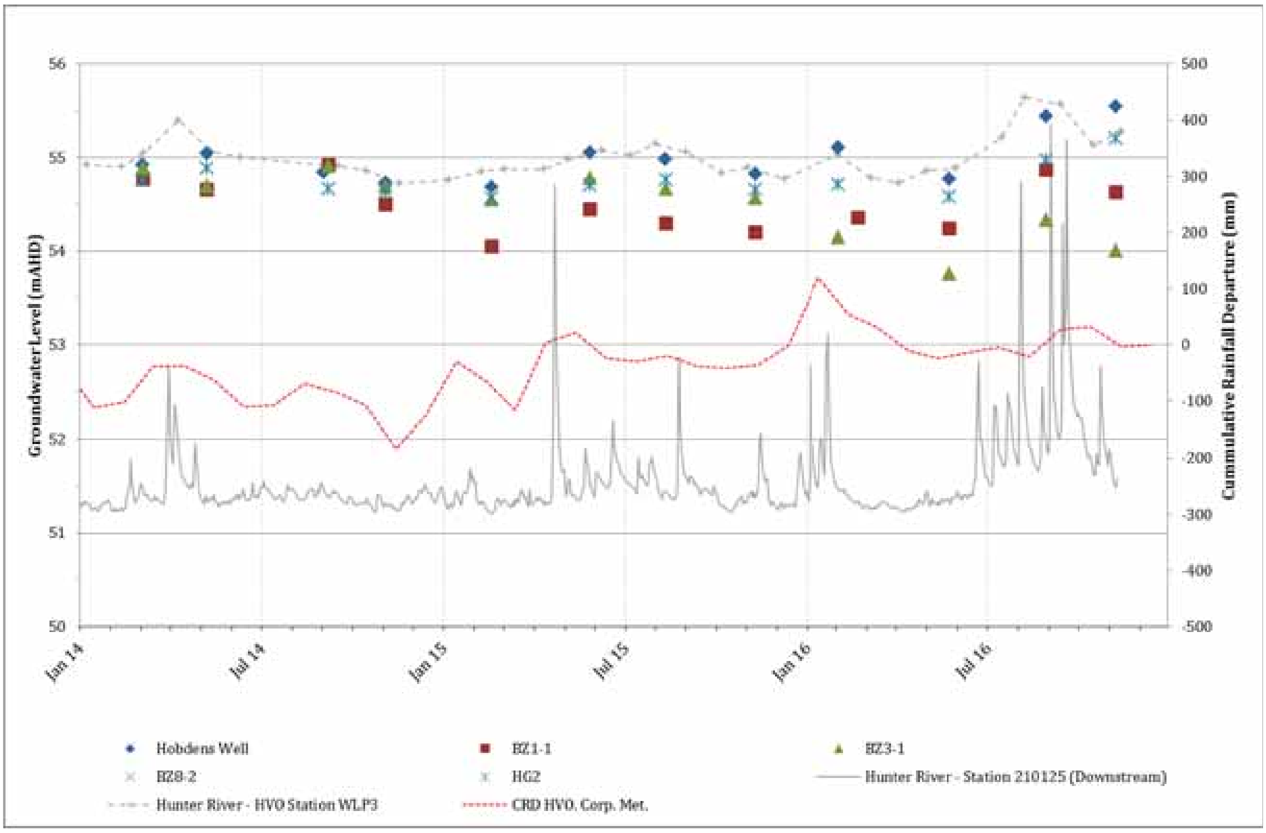


Figure C.4 Cheshunt South – Alluvium

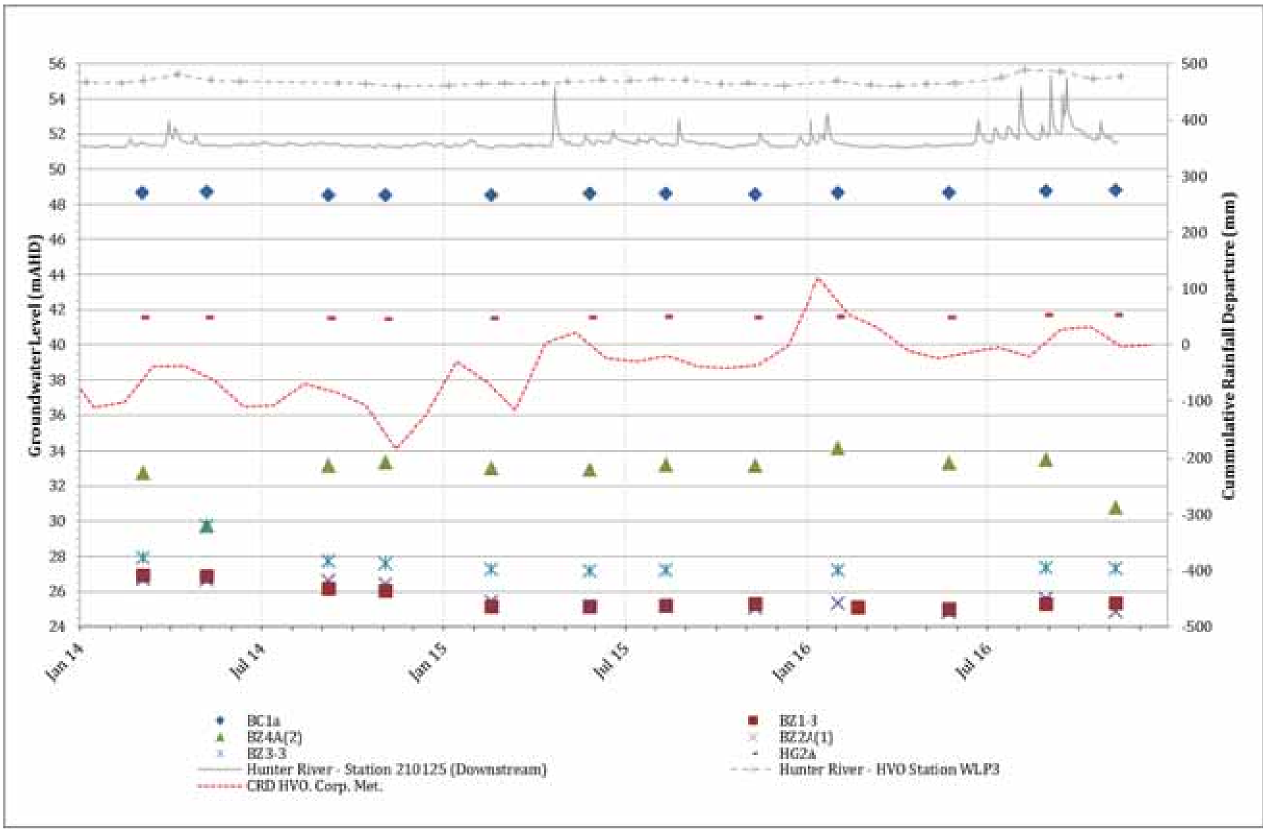


Figure C.5 Cheshunt South – Mount Arthur Seam

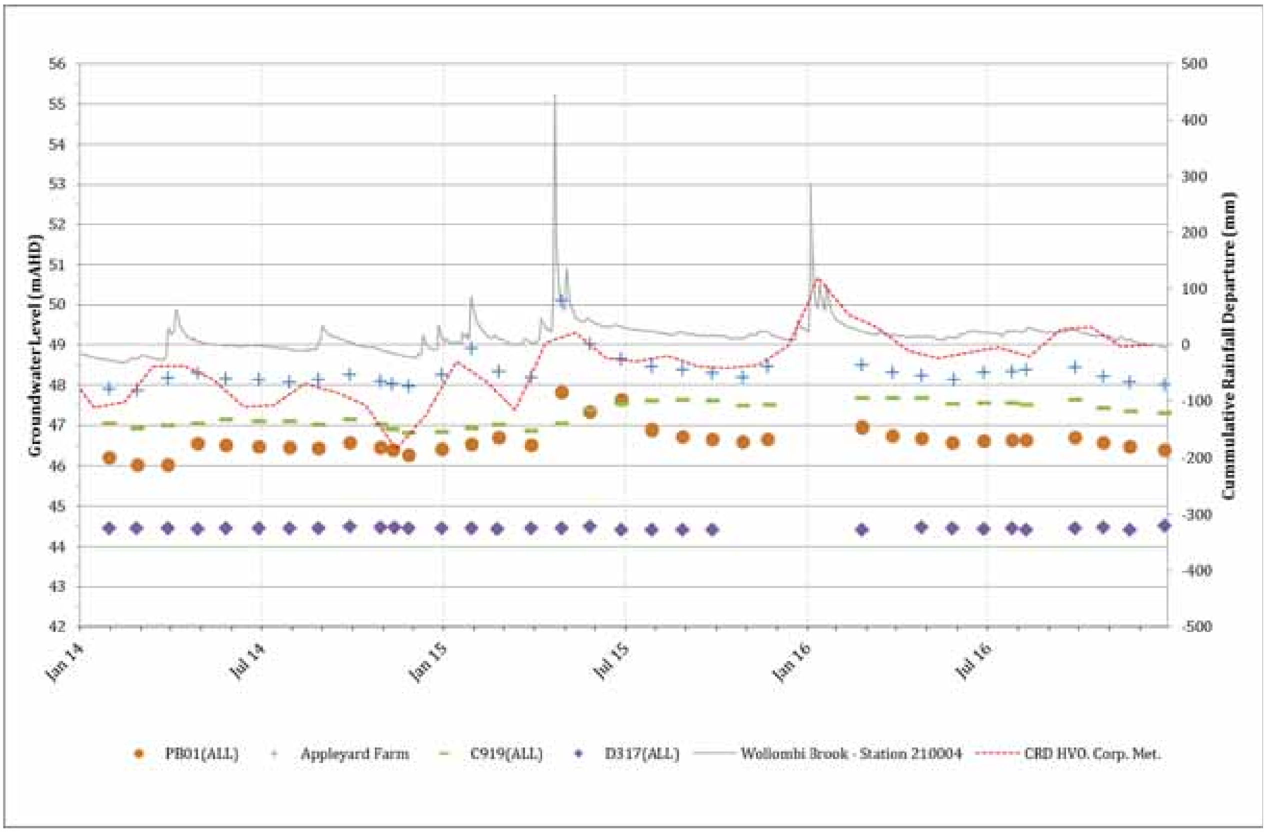


Figure C.6 South Lemington - Alluvium

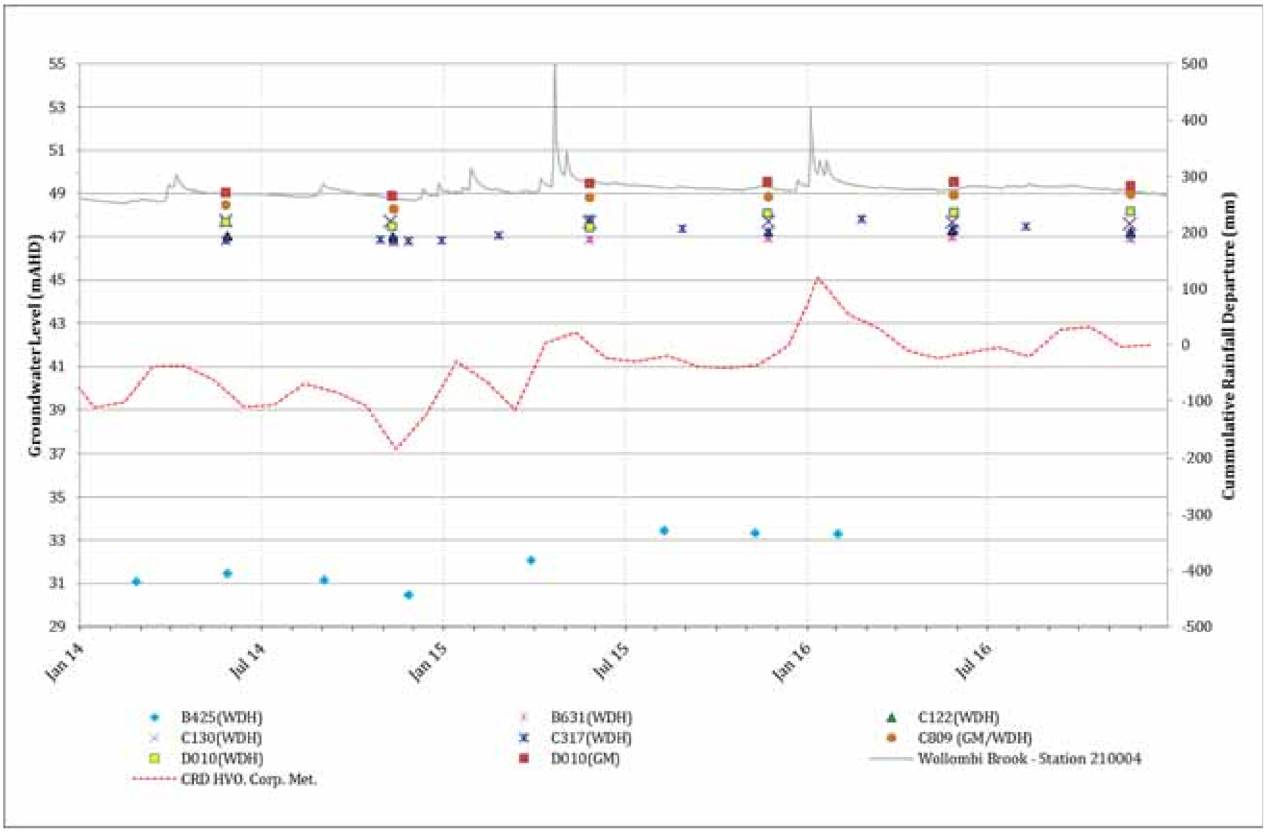


Figure C.7 South Lemington – Woodlands Hill and Glen Munro Seam

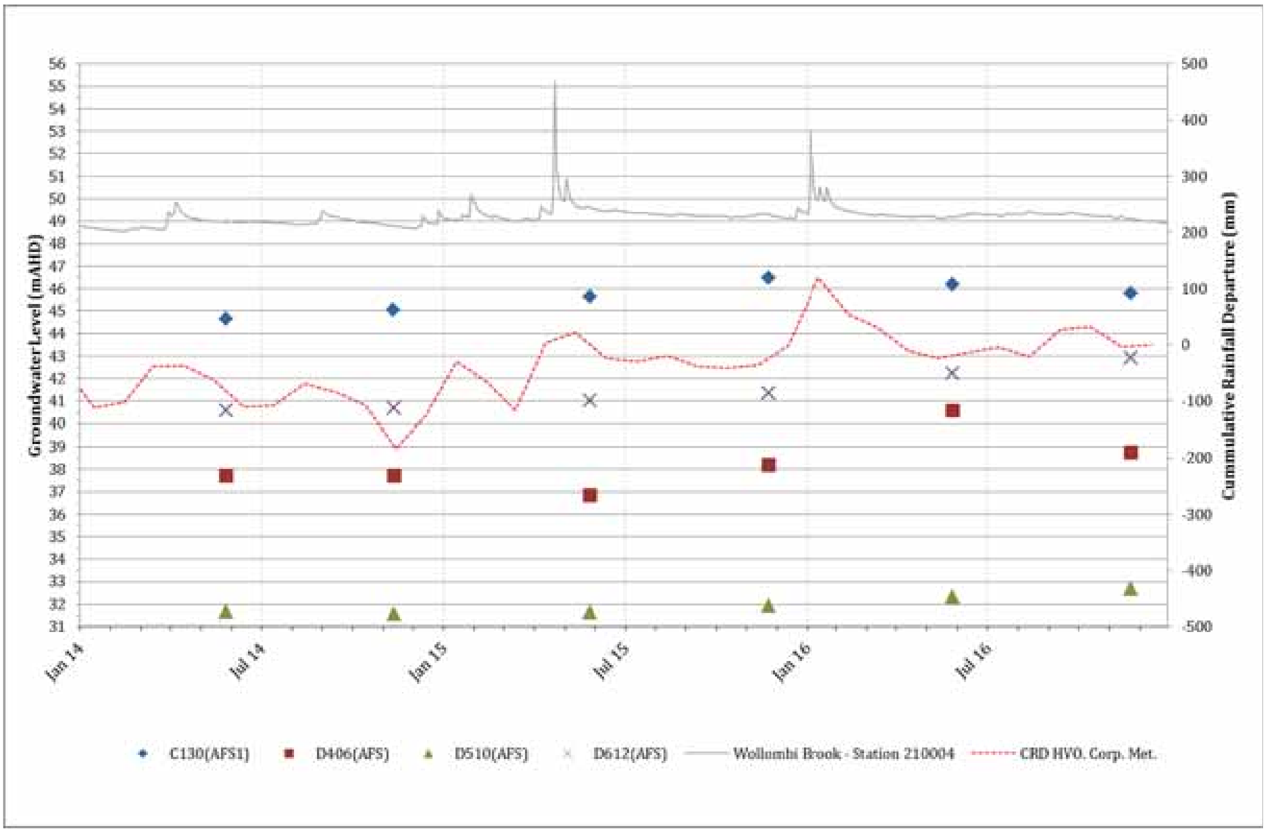


Figure C.8 South Lemington – Arrowfield Seam

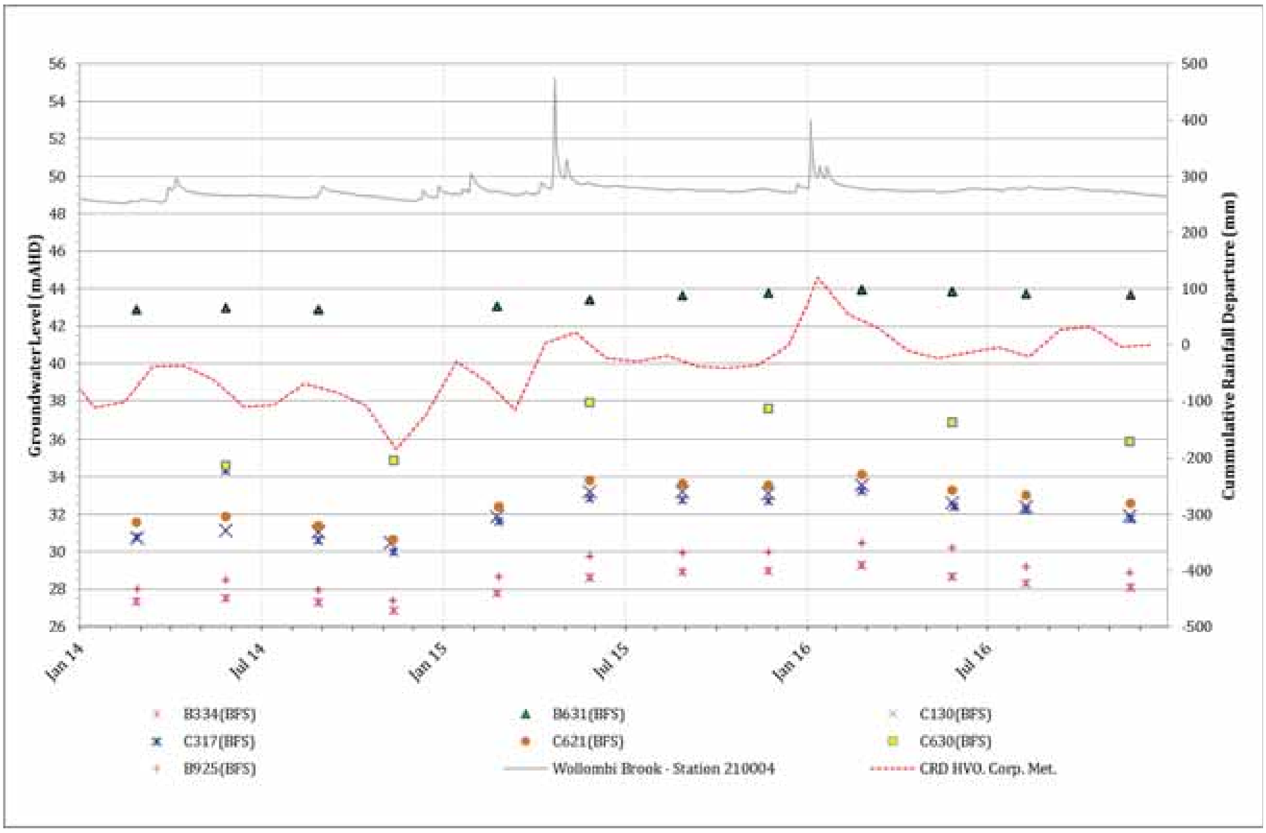


Figure C.9 South Lemington– Bowfield Seam – southern bores

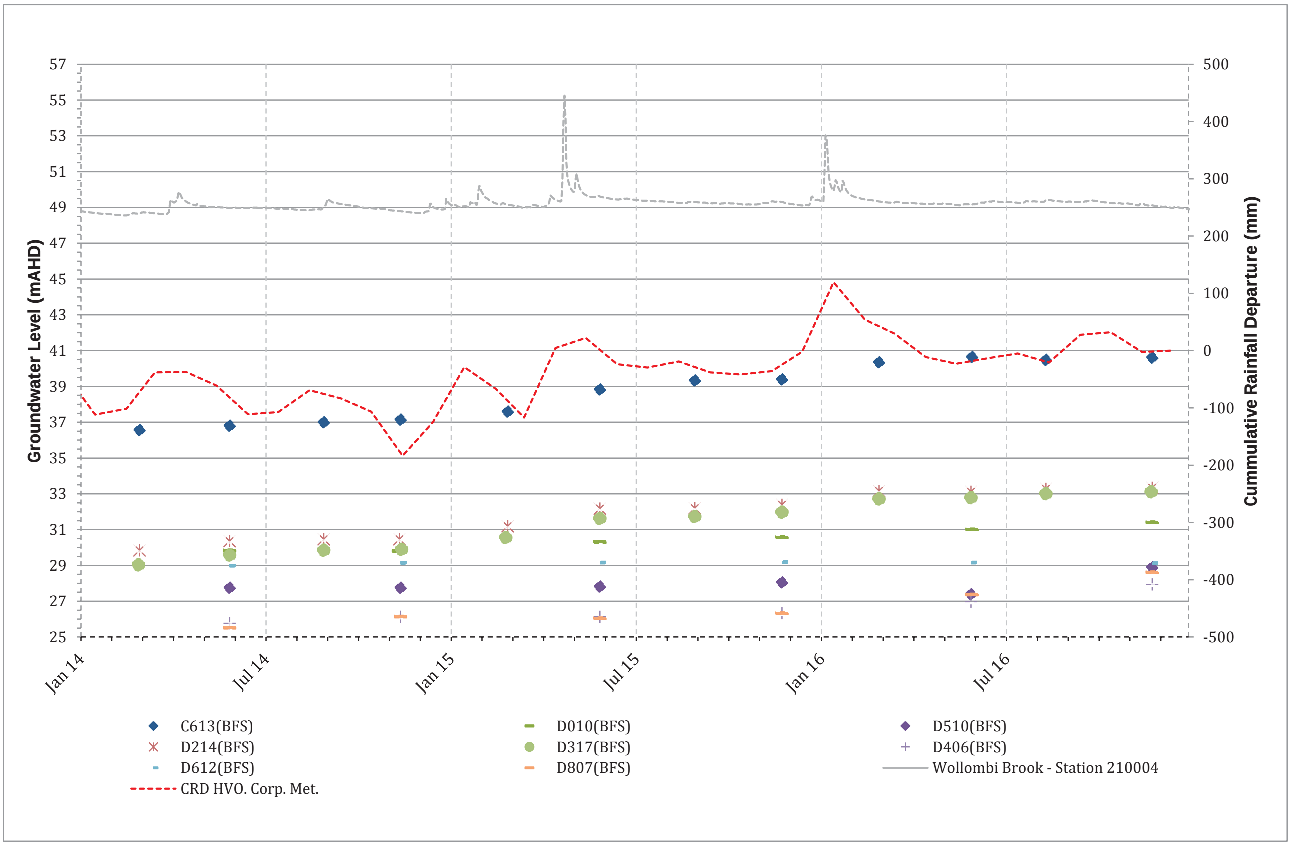


Figure C.10 South Lemington– Bowfield Seam – northern bores

Appendix D LUG monitoring data

Table D 1 Summary of monitoring bores near LUG Bore

Bore ID	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Top of screen (mbGL)	Base of screen (mbGL)	Lithological description
Appleyard Farm	315491	6394639	43.4	0.8	10.0	7.0	10.0	Alluvium
C919(ALL)	315192	6395655	58.0	0.3	11.5	-	-	Alluvium
D317(ALL)	315044	6396018	59.5	0.3	14.7	9.2	12.2	Alluvium
PB01(ALL)	314754	6396026	55.0	-	-	-	-	Alluvium
C130(AFS1)	316400	6394916	63.0	0.3	42.2	-	-	Arrowfield Seam
D406(AFS)	313931	6396074	57.0	0.3	-	-	-	Arrowfield Seam
D510(AFS)	314380	6396141	54.8	0.3	30.5	25.5	30.5	Arrowfield Seam
D612(AFS)	314524	6396314	62.0	0.4	0.0	-	-	Arrowfield Seam
B334(BFS)	316684	6394088	73.0	0.3	51.8	58.5	-	Bowfield Seam
B631(BFS)	316425	6394319	72.0	0.3	36.1	78.0	-	Bowfield Seam
B925(BFS)	315921	6394604	65.0	0.4	41.2	81.0	-	Bowfield Seam
C130(BFS)	316400	6394916	63.0	0.0	64.5	55.0	61.0	Bowfield Seam
C317(BFS)	315054	6395007	60.0	0.4	76.2	-	-	Bowfield Seam
C613(BFS)	314688	6395243	63.0	0.3	85.5	-	-	Bowfield Seam
C621(BFS)	315421	6395321	58.0	0.3	57.5	-	-	Bowfield Seam
C630(BFS)	316378	6395306	69.0	0.3	49.1	-	-	Bowfield Seam
D010(BFS)	314355	6395687	56.0	0.4	68.1	-	-	Bowfield Seam
D214(BFS)	314768	6395831	56.5	0.3	53.5	43.0	52.5	Bowfield Seam
D317(BFS)	315043	6396019	59.5	0.3	44.0	39.0	44.2	Bowfield Seam
D406(BFS)	313931	6396074	57.0	0.3	61.3	-	-	Bowfield Seam
D510(BFS)	314380	6396141	54.8	0.3	38.0	34.0	38.0	Bowfield Seam
D612(BFS)	314524	6396314	62.0	0.3	35.1	-	-	Bowfield Seam
D807(BFS)	314002	6396484	59.7	0.4	41.0	36.0	41.0	Bowfield Seam
D010(GM)	314355	6395687	56.0	-	-	-	-	Glen Munro Seam
C130(ALL)	316400	6394916	63.0	0.3	17.0	-	-	Interburden?
B425(WDH)	316010	6395024	58.0	-	55.0	-	-	Woodlands Hill Seam
B631(WDH)	316424	6394319	72.0	-	30.7	-	-	Woodlands Hill Seam
C122(WDH)	315501	6395007	58.0	0.3	22.7	-	-	Woodlands Hill Seam
C130(WDH)	316400	6394916	63.0	0.4	21.6	-	-	Woodlands Hill Seam
C317(WDH)	315054	6395007	60.0	0.2	33.9	-	-	Woodlands Hill Seam
C809 (GM/WDH)	314207	6395493	59.0	0.3	28.7	28.0	38.0	Woodlands Hill Seam
D010(WDH)	314355	6395687	56.0	0.3	17.0	-	-	Woodlands Hill Seam

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Appendix 3

Rehabilitation Table

Annual Rehabilitation Report Form, Rehabilitation Maps and Rehabilitation Summary

Annual Rehabilitation Report Form – Mines
Year Ending: 2016
Mine: Hunter Valley Operations
Company: Rio Tinto Coal Australia – Coal and Allied
Plans Attached:
Hunter Valley Operations – AEMR 2016
Approved Mining Operations Plan:
HVO South MOP (2015 – 2018) – Approval Date 17/12/2015
HVO North MOP (2015 – 2018) – Approval Date 19/02/2016
Total Area Covered by Mining Operations Plan:
HVO North MOP – 5,434ha
HVO South MOP – 5,221ha
Total Area Covered by Mining Lease for This Mine: 10,655ha

Table 1: Rehabilitation Progress 2016 - HVO North (includes Newdell)

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	211.19	211.4
	2B	Water Management Areas	Water Management Areas	16.19	16.3
	3C	Infrastructure Area	Rehabilitation Area - Pasture	166.6	169.1
	3D	Infrastructure Area	Rehabilitation Area - Woodland	3.56	0.9
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	113.11	117.7
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	62.64	63.0
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	718.27	737.9
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	674.17	619.8
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 2 and 3 Land	2.76	0
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	40.21	22.6
	Total Active			2008.7	1958.7
1.2 Decommissioning	Total - Decommissioning			0.0	0
1.3 Landform Establishment	Total - Landform Establishment			0 (Included in 1.1)	4.33 (Included in 1.1)
1.4 Growth Medium Development	Total - Growth Medium Development			0 (Included in 1.1)	5.14 (Included in 1.1)
1.5 Ecosystem and Land Use Establishment	1A	Final Void	Final Void	7.48	7.9
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0	0.1
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	0	2.9
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	0.27	0.3
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	141.16	105
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	80.67	137.4
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	0	0.6
	Total - Ecosystem and Land Use Establishment			229.58	254.2
1.6 Ecosystem and	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	93.91	36.6

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
Land Use Development	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	28.28	28.2
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	918.47	939.99
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	469.71	414.4
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 1 and 2 Land	72.3	72.3
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	0	52.3
	Total - Ecosystem and Land Use Development			1582.7	1543.8
1.7 Rehabilitation Complete	Total - Rehabilitation Complete			0	0
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	218.67	219.3
	2B	Water Management Areas	Water Management Areas	16.19	16.3
	3C	Infrastructure Area	Rehabilitation Area - Pasture	166.6	169.1
	3D	Infrastructure Area	Rehabilitation Area - Woodland	3.56	1.0
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	207.02	157.2
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	91.19	91.5
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	1777.9	1782.9
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	1224.55	1171.6
	5E	Overburden Emplacement Area	Rehabilitation Area - Class 1 and 2 Land	75.06	72.3
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	40.21	75.5
	Total Footprint			3820.95	3756.69

Table 2: Rehabilitation Progress 2016 - HVO South

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	264.26	274.5
	2B	Water Management Areas	Water Management Areas	20.29	11.8
	2C	Water Management Areas	Rehabilitation Area - Pasture	0	6.7
	2D	Water Management Areas	Rehabilitation Area - Woodland	0	1.8
	3C	Infrastructure Area	Rehabilitation Area - Pasture	99.67	100.6
	3D	Infrastructure Area	Rehabilitation Area - Woodland	8.12	8.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	1.94	4.5
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	8.4	9.8
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	732.72	681.1
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	584.34	544
	Total Active			1719.7	1643.3
1.2 Decommissioning	Total - Decommissioning			0.0	0
1.3 Landform Establishment	Total - Landform Establishment			6.29 (Included in 1.1)	14.2 (Included in 1.1)
1.4 Growth Medium Development	Total - Growth Medium Development			6.02 (Included in 1.1)	14.5 (Included in 1.1)
1.5 Ecosystem and Land Use Establishment	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	18.21	18.2
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	40.74	40.7
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	236.15	195.8
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	132.52	154.1
	Total - Ecosystem and Land Use Establishment			427.62	408.8
1.6 Ecosystem and Land Use Development	3C	Infrastructure Area	Rehabilitation Area - Pasture	0.69	0.7
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	21.73	10.7

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	17.71	19.9
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	222.71	304.9
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	230.84	254.0
	Total - Ecosystem and Land Use Development			493.68	590.2
1.7 Rehabilitation Complete	Total - Rehabilitation Complete			0	0
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	264.26	274.5
	2B	Water Management Areas	Water Management Areas	20.29	11.8
	2C	Water Management Areas	Rehabilitation Area - Pasture	0	6.7
	2D	Water Management Areas	Rehabilitation Area - Woodland	0	1.8
	3C	Infrastructure Area	Rehabilitation Area - Pasture	100.36	101.3
	3D	Infrastructure Area	Rehabilitation Area - Woodland	8.12	8.5
	4C	Tailings Storage Facility	Rehabilitation Area - Pasture	41.88	33.4
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	66.85	70.4
	5C	Overburden Emplacement Area	Rehabilitation Area - Pasture	1191.58	1181.8
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	947.7	952.1
	Total Footprint			2641.04	2642.3

Table 3: Weed Control

	Area (ha)
3.1 Approx. area adversely affected by weeds as of the date of this report	Not Available
3.2 Area treated for weed control during the period covered by the report	463.25
3.3 Give summary of control strategies used and verification by approval agency(s)	
Species targeted in rehabilitation areas during 2016 included: galenia, Rhodes grass, green panic, couch grass, *Acacia saligna*, mustard weed (Brassica), farmers friend (*Bidens pilosa*) and paddys lucerne (*Sida rhombifolia*).	

Table 4: Management of Rehabilitation Areas

	Area (ha)
4.1 Area treated with maintenance fertiliser	0ha
4.2 Area treated by rotational grazing, cropping or slashing	1,003ha
Give Summary	719ha HVO North rehabilitation area licence agreement in place for grazing. Temporary grazing licences aimed at reducing fuel loads are in place for a further 212ha of rehabilitated land across HVO North.

Table: 5 Variations to Rehabilitation Program

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan.	HVO North - Substantially HVO South – Yes
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	
Actual rehabilitation completed in HVO North during period 2015 to 2016 = 84.6ha. MOP target for rehabilitation in HVO North during period 2015 to 2016 = 117.9ha. Dump progress in West Pit areas has been slower than the MOP forecast. The reduction in rehabilitation areas in HVO North has been offset by equivalent areas in HVO South addressing high visibility areas in Cheshunt and Riverview Pits.	

Table 6: Planned Operations During the Next Report Period

	Area (ha)
6.1 Area estimated to be disturbed	151.2ha
6.2 Area estimated to be rehabilitated	100ha

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Appendix 4

Rehabilitation and Disturbance Summary and Maps

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Cheshunt (Barrys slope)	Diverse Cover Crop	313,296.4 E 6,401,539.4 N	32.3	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10-12 degrees) with a primarily northerly aspect. ▪ Drainage is via contours reporting to an engineered rock chute and dam at base of slope. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles and reclaimed Riverview rehabilitation disturbance was spread at a nominal thickness of 100mm. ▪ Mixed source compost was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, and aerating. ▪ Late Winter Rehab Blend (7.9ha at 30kg/ha); rye/legume/herb) and Spring Summer Rehab Blend (24.2ha at 35kg/ha); millet/legume/herb) was broadcast into an aerated pattern.
Lemington South	Native Woodland	317,062.8 E 6,394,935.8 N	4.0	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (8-10 degrees) with a primarily westerly aspect. ▪ Drainage is via contours reporting to existing wider area drainage. ▪ Landform surface preparation comprised bulk shaping and removal of rock material as necessary. ▪ In-situ loamy sand spoil was supplemented with loamy sand topsoil from stockpiles and spread at a minimum thickness of 100mm. ▪ Mixed source compost was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included rock & timber picking, aerating, and pre-sowing herbicide application. ▪ Native Woodland Mix was hydroseeded to an aerated pattern at 28.5kg/ha.
Riverview (Western	Diverse Cover Crop	311,266.5 E 6,398,160.9 N	8.4	▪ The landform was constructed from a waste emplacement. ▪ The area is steeply sloping (13-14 degrees) with south-westerly aspect.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Amphitheatre)				▪ Drainage is via northerly draining contours to an engineered rock chute which reports to the Riverview Void via further drains. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil reclaimed from Riverview rehabilitation disturbance stripping was spread at a nominal thickness of 100mm. ▪ Mixed source compost was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, and aerating. ▪ Autumn Winter Rehab Blend comprising (barley/ryegrass/legume/herb) was broadcast into an aerated pattern at 78kg/ha.
West Pit North (former N2 crib hut)	Native Woodland	309,791.8 E 6,410,831.2 N	6.2	▪ The landform was constructed from a waste emplacement. ▪ The area is generally flat or gently sloping (0-4 degrees) with a northerly aspect. ▪ Drainage is via overland flow to local drainage channels and habitat ponds. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles (c.2015) was spread at a nominal thickness of 100mm. ▪ Mixed source compost was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, and aerating. ▪ Native Woodland Mix was drilled into an aerated pattern at 13.8kg/ha.
West Pit North (RL230 level)	Native Pasture / Light Woodland	307,890.7 E 6,410,007.1 N	6.1	▪ The landform was constructed from a waste emplacement. ▪ The area is generally flat and without dominant aspect. ▪ Drainage is via overland flow to local drainage channels and habitat ponds, or to adjacent rehabilitation areas and subsequently to an

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				engineered rock structure located to the west. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Mixed source compost (3.1ha) and green waste mulch (3.0ha) was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, aerating, and pre-sowing herbicide application. ▪ Native Pasture/Light Woodland Mix was drilled into an aerated pattern at 12.7kg/ha.
West Pit South (RL230 level)	Native Woodland	308,341.0 E 6,408,346.2 N	4.0	▪ The landform was constructed from a waste emplacement. ▪ The area is generally flat and without dominant aspect. ▪ Drainage is via overland flow to local drainage channels and habitat ponds, or to adjacent rehabilitation areas and subsequently to an engineered rock structure located to the south-west. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from ahead of mine topsoil stripping was spread at a nominal thickness of 100mm. ▪ Mixed source compost (1.7ha) and green waste mulch (2.3ha) was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, aerating, and pre-sowing herbicide application. ▪ Native Woodland Mix was drilled into an aerated pattern at 13.8kg/ha.
West Pit South (S2 slope)	Diverse Cover Crop	307,890.7 E 6,408,452.3 N	8.1	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10-12 degrees) with a primarily westerly aspect. ▪ Drainage is via contours reporting to an engineered rock chute and existing wider area drainage.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Mixed source compost was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included windrowing, rock picking, aerating, and pre-sowing herbicide application. ▪ Spring Summer Rehab Blend (millet/legume/herb) was broadcast into an aerated pattern at 35kg/ha.
Wilton (RL210 level)	Native Pasture / Light Woodland	311,061.7 E 6,398,463.1 N	3.7	▪ The landform was constructed from a waste emplacement. ▪ The area is typically flat (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow. Drainage reports to adjacent rehabilitation and mine areas. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from stockpiles (c.2014) and ahead of mining topsoil stripping was spread at a nominal thickness of 100mm. ▪ Green waste mulch was applied at a rate of 100t/ha. ▪ Gypsum was applied at a rate of 10t/ha. ▪ Growth medium preparation included rock picking as required, and aerating. ▪ Native Pasture/Light Woodland Mix was drilled into an aerated pattern at 12.7kg/ha.

Autumn Winter Rehab Blend	Composition (% by weight)
Forage Barley	64
Ryegrass	13
Forage Brassica	3
Lucerne	10
Clover	10

Late Winter Rehab Blend	Composition (% by weight)
Rye	33
Lucerne	27
Clovers	20
Chricory	10
Plantain	10

Spring Summer Rehab Blend	Composition (% by weight)
Millet	57
Chicory	6
Clover	7
Lucerne	21
Bean	9

DISTURBANCE PHASES

- ACTIVE MINING AREA
- GROWTH MEDIUM DEVELOPMENT
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOPSOIL STOCKPILE
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
Full Plan	30/03/2017	Mine surveying content depicted on the plan supplied by others	B. Nichols
Full Plan	30/03/2017	Domain boundaries supplied by others	B. Nichols
Full Plan	30/03/2017	Disturbance limits supplied by others	B. Nichols
Full Plan	30/03/2017	Mining tenement & lease boundaries supplied by others	B. Nichols
Full Plan	30/03/2017	Expected mining area supplied by others	B. Nichols
Full Plan	30/03/2017	Rehabilitation data & phases supplied by others	B. Nichols
Full Plan	30/03/2017	Vegetation information supplied by others	B. Nichols

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- 2016 AERIAL CONTOUR (2M)

REHABILITATION PHASES

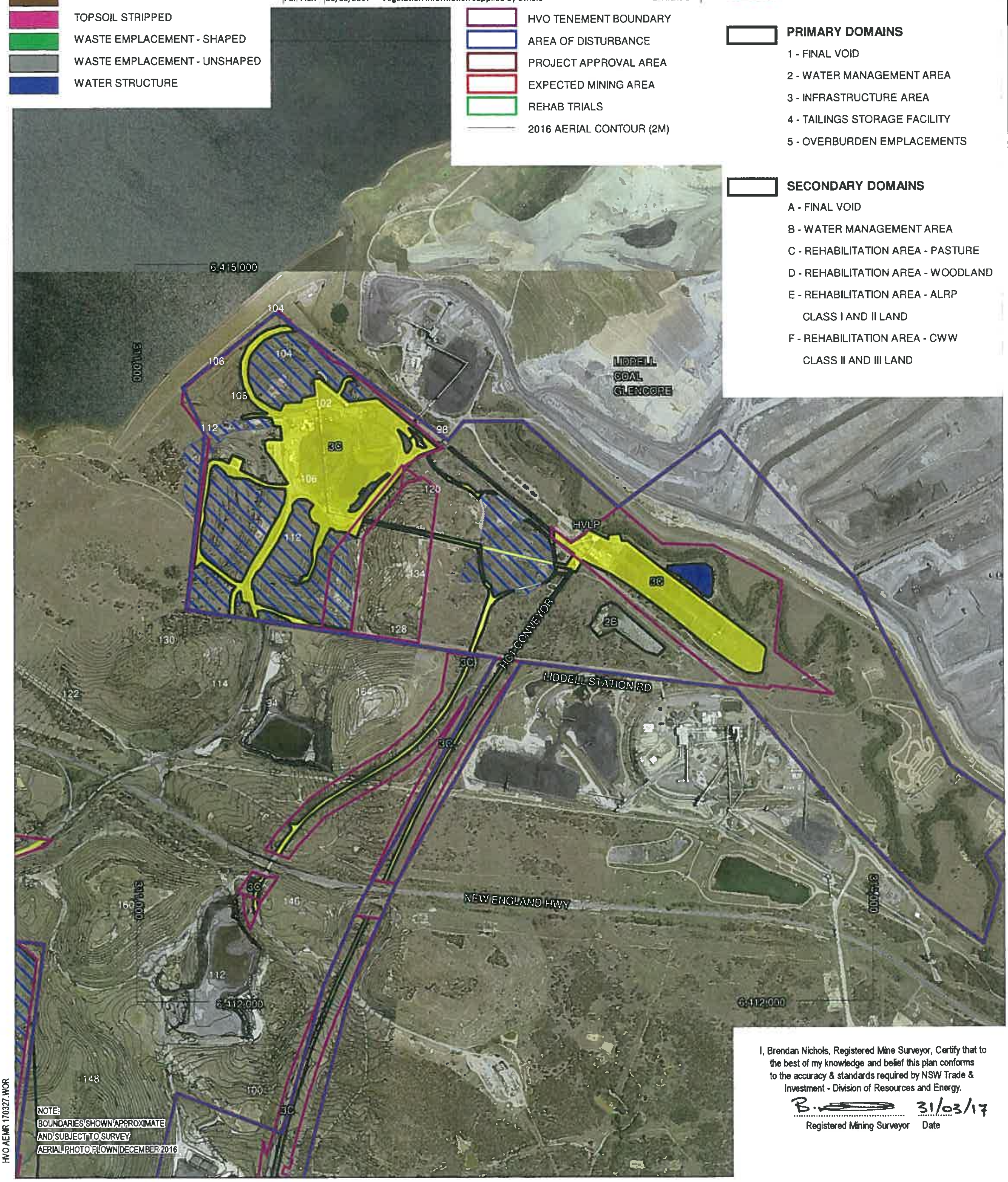
- DECOMISSIONING
- LANDFORM ESTABLISHMENT
- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

1 - FINAL VOID
2 - WATER MANAGEMENT AREA
3 - INFRASTRUCTURE AREA
4 - TAILINGS STORAGE FACILITY
5 - OVERBURDEN EMPLACEMENTS

SECONDARY DOMAINS

A - FINAL VOID
B - WATER MANAGEMENT AREA
C - REHABILITATION AREA - PASTURE
D - REHABILITATION AREA - WOODLAND
E - REHABILITATION AREA - ALRP CLASS I AND II LAND
F - REHABILITATION AREA - CWW CLASS II AND III LAND



HVO AEMR 170327.WOR

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. [signature] 31/03/17

Registered Mining Surveyor Date

COAL & ALLIED

N W E S

Scale 1:20,000 (A4)
Projection: MGA Zone 56
Date: 30/03/17

0 400 800
METRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - HVLP NLP - 2016

REHABILITATION PHASES

- DECOMISSIONING
- LANDFORM ESTABLISHMENT
- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

1 - FINAL VOID
2 - WATER MANAGEMENT AREA
3 - INFRASTRUCTURE AREA
4 - TAILINGS STORAGE FACILITY
5 - OVERBURDEN EMPLACEMENTS

SECONDARY DOMAINS

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C - REHABILITATION AREA - PASTURE
D - REHABILITATION AREA - WOODLAND
E - REHABILITATION AREA - ALRP CLASS I AND II LAND
F - REHABILITATION AREA - CWW CLASS II AND III LAND

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- 2016 AERIAL CONTOUR (2M)

DISTURBANCE PHASES

- ACTIVE MINING AREA
- GROWTH MEDIUM DEVELOPMENT
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOPSOIL STOCKPILE
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

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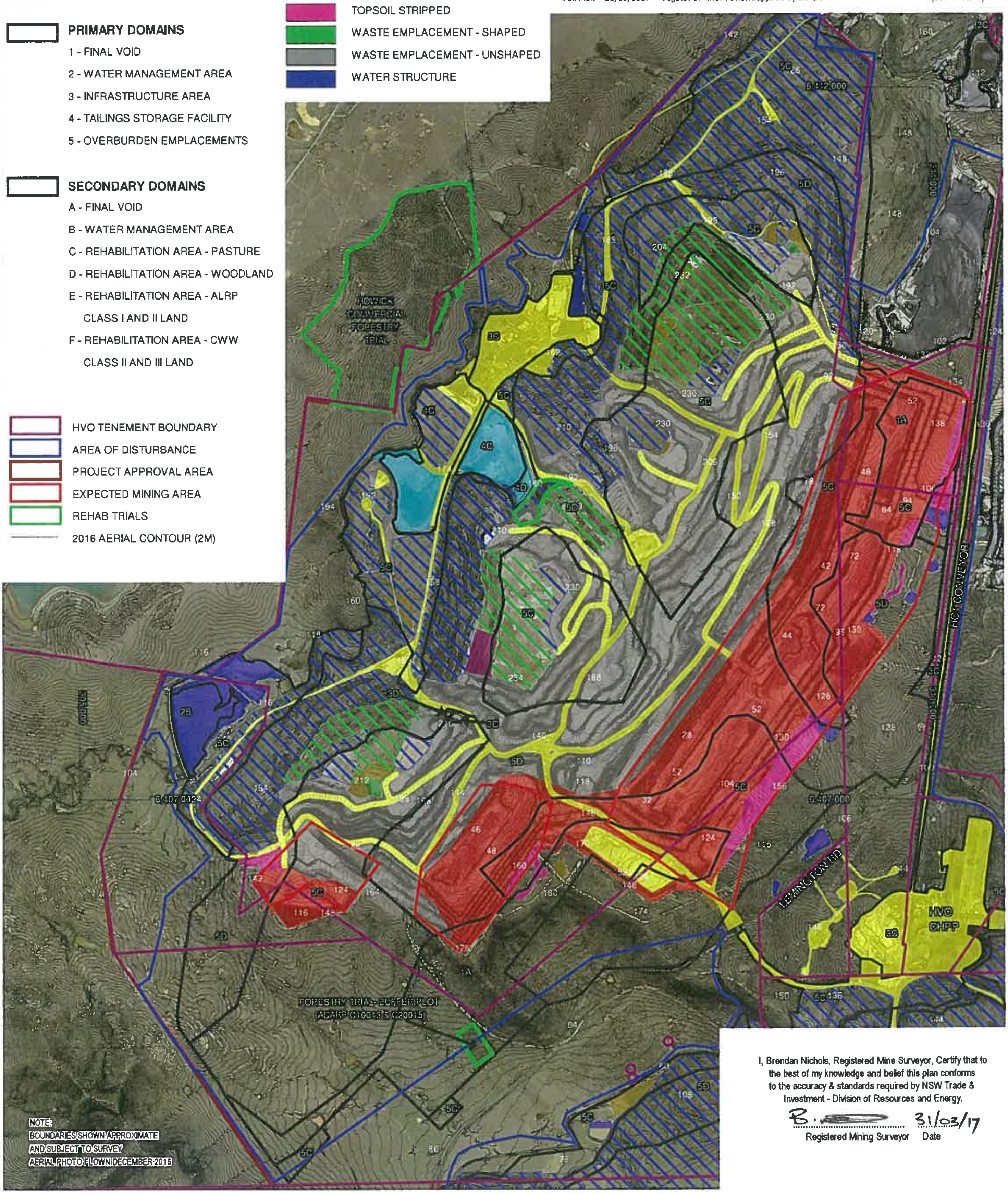

HVO AEMR 170327.WOR

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. 31/03/17

Registered Mining Surveyor   Date

COAL & ALLIED

Scale 1:35,000 (A4)
Projection: MGA Zone 56
Date: 30/03/17

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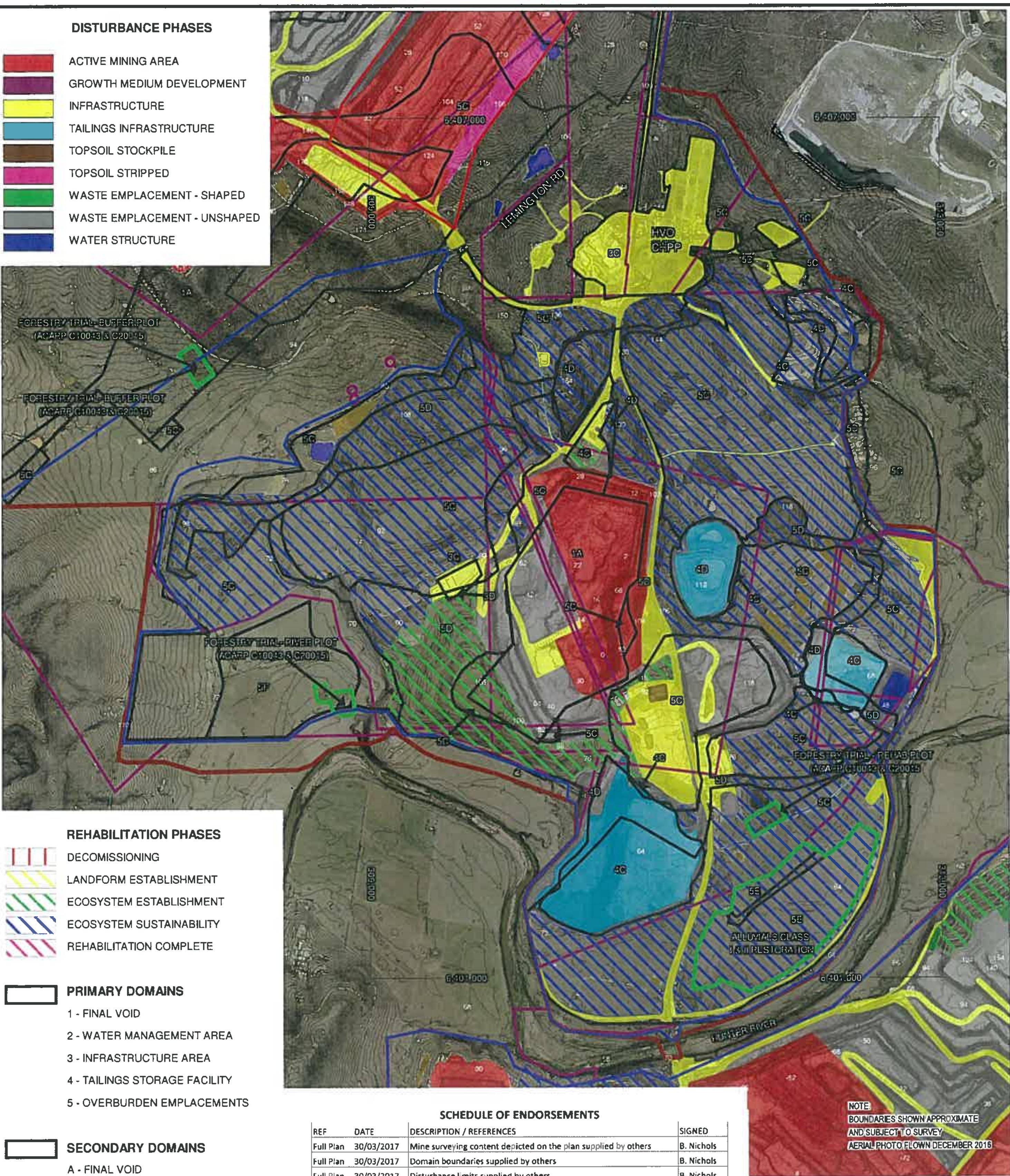
KILOMETRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - West Pit - 2016



DISTURBANCE PHASES

- ACTIVE MINING AREA
- GROWTH MEDIUM DEVELOPMENT
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOPSOIL STOCKPILE
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

REHABILITATION PHASES

- DECOMISSIONING
- LANDFORM ESTABLISHMENT
- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

1 - FINAL VOID
2 - WATER MANAGEMENT AREA
3 - INFRASTRUCTURE AREA
4 - TAILINGS STORAGE FACILITY
5 - OVERBURDEN EMPLACEMENTS

SECONDARY DOMAINS

A - FINAL VOID
B - WATER MANAGEMENT AREA
C - REHABILITATION AREA - PASTURE
D - REHABILITATION AREA - WOODLAND
E - REHABILITATION AREA - ALRP CLASS I AND II LAND
F - REHABILITATION AREA - CWW CLASS II AND III LAND

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Full Plan	30/03/2017	Rehabilitation data & phases supplied by others	B. Nichols
Full Plan	30/03/2017	Vegetation information supplied by others	B. Nichols

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- 2016 AERIAL CONTOUR (2M)

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. [signature] 31/03/17
Registered Mining Surveyor Date

HVO AEMR 170327.WOR

COAL & ALLIED

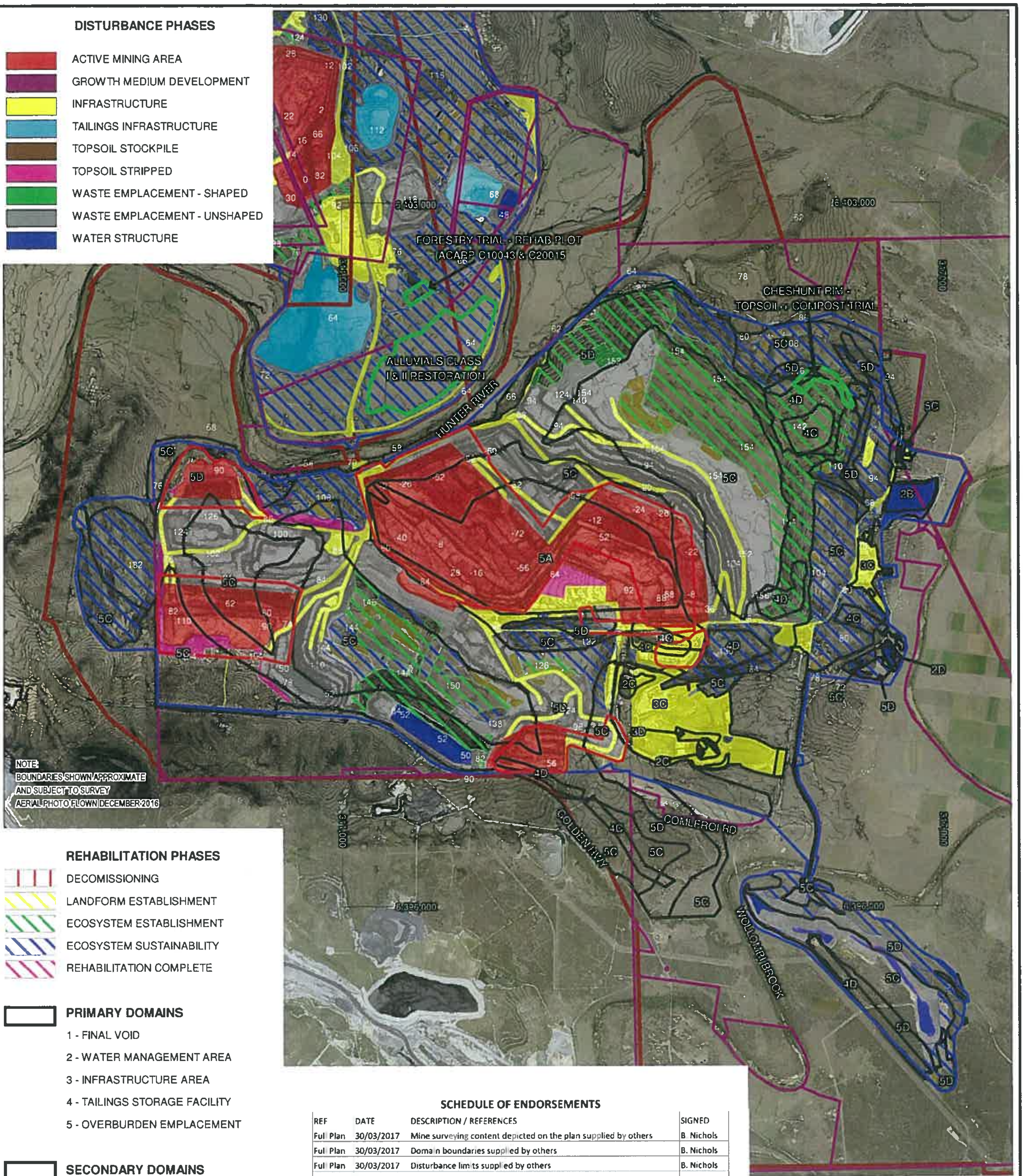
N W E S

Scale 1:35,000 (A4)
Projection: MGA Zone 56
Date: 30/03/17

0 0.5 1
KILOMETRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - Carrington Pit - 2016



DISTURBANCE PHASES

- ACTIVE MINING AREA
- GROWTH MEDIUM DEVELOPMENT
- INFRASTRUCTURE
- TAILINGS INFRASTRUCTURE
- TOPSOIL STOCKPILE
- TOPSOIL STRIPPED
- WASTE EMPLACEMENT - SHAPED
- WASTE EMPLACEMENT - UNSHAPED
- WATER STRUCTURE

REHABILITATION PHASES

- DECOMISSIONING
- LANDFORM ESTABLISHMENT
- ECOSYSTEM ESTABLISHMENT
- ECOSYSTEM SUSTAINABILITY
- REHABILITATION COMPLETE

PRIMARY DOMAINS

1 - FINAL VOID
2 - WATER MANAGEMENT AREA
3 - INFRASTRUCTURE AREA
4 - TAILINGS STORAGE FACILITY
5 - OVERBURDEN EMPLACEMENT

SECONDARY DOMAINS

A - FINAL VOID
B - WATER MANAGEMENT AREA
C - REHABILITATION AREA - CLASS 1 AND 2 LAND
D - REHABILITATION AREA - PASTURE
E - REHABILITATION AREA - WOODLAND

SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION / REFERENCES	SIGNED
Full Plan	30/03/2017	Mine surveying content depicted on the plan supplied by others	B. Nichols
Full Plan	30/03/2017	Domain boundaries supplied by others	B. Nichols
Full Plan	30/03/2017	Disturbance limits supplied by others	B. Nichols
Full Plan	30/03/2017	Mining tenement & lease boundaries supplied by others	B. Nichols
Full Plan	30/03/2017	Expected mining area supplied by others	B. Nichols
Full Plan	30/03/2017	Rehabilitation data & phases supplied by others	B. Nichols
Full Plan	30/03/2017	Vegetation information supplied by others	B. Nichols

- HVO TENEMENT BOUNDARY
- AREA OF DISTURBANCE
- PROJECT APPROVAL AREA
- EXPECTED MINING AREA
- REHAB TRIALS
- 2016 AERIAL CONTOUR (2M)

I, Brendan Nichols, Registered Mine Surveyor, Certify that to the best of my knowledge and belief this plan conforms to the accuracy & standards required by NSW Trade & Investment - Division of Resources and Energy.

B. [signature] 31/03/17
Registered Mining Surveyor Date

HVO AEMR 170327.WOR

COAL & ALLIED

Scale 1:50,000 (A4)
Projection: MGA Zone 56
Date: 30/03/17

0 0.8 1.6
KILOMETRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - HVO South - 2016